INVESTIGATIONS

INTO

TUBERCULOSIS

IN

UGANDA

By

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CONTENTS

PART I

GENERAL INTRODUCTION

The subject of tuberculosis in Eastern Africa is one which up to the present time has not received much attention.

As recently as fifteen years ago it was considered a rare disease in Uganda, but the passage of time has revealed the disease to be comparatively common both in man and animals.

Examination of the statistics inevitably suggests that tuberculosis is definitely on the increase, but at the same time it must be remembered that the develop--ment of the country has advanced with amazing rapidity during the last fifteen years.

Medical and Veterinary Services have expanded and the administration of the country is closer and more detailed, so that too much significance should not be attached to statistics however suggestive they might appear.

It must be admitted, however, that tubercu--losis is increasing and will continue to do so until civilisation begins to assert itself in the form of prevention and control of this disease which, even in old established countries, is one of the biggest problems of the time.

The general situation as regards tuberculosis is not comparable to that in civilised European communities. Up to the present time tuberculosis has been overshadowed by the more dramatic diseases which have occurred in Tropical Africa in epidemic form since time immemorial. Sleeping Sickness and Plague may be mentioned from the human side, whilst Rinderpest, Pleuro-Pneumonia , East

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Coast Fever, etc., have attracted the whole attention of the Veterinary authorities. In the discussion of a paper by Hodson (1929) , Col. S. Lyle Cummins stated : " The Medical profession has paid close attention to the more dramatic and swift tropical diseases " ; the same could be said of the Veterinary side. With increased develop--ment in tropical countries tuberculosis will inevitably compel more attention than previously.

From the bacteriological point of view Uganda presents an entirely new field of investigation. The discovery of the disease in cattle and man, and the close contact between the two in Uganda, demanded investigation as to the relation of tuberculosis in the African native and his domestic stock.

Nothing was known of the type of tubercle bacillus infecting man, or whether tuberculosis in African cattle was similar bacteriologically to the recognised European disease, as both human beings and animals live under entirely different conditions to their prototypes in more civilised countires.

The discovery of tuberculosis in sheep and goats is a matter of interest both bacteriologically and from the public health standpoint because of the rarity of the disease in these animals and the local custom of housing them with the people.

Avian tuberculosis has not, up to the present time, been recorded in Uganda.

Uganda is situated on the North and Western shores of Lake Victoria Nyanza and is some 700 miles from the East coast of Africa.

The altitude varies from 2,000 ft. in the Nile valley in the North, up to 8,000 - 9,000 ft. in the South and West.

The rainfall (vide map) varies considerably but is generally highest near Lake Victoria. In this connection it is interesting to note that tuberculosis of cattle is frequent in a particularly dry area whilst the human disease, apart from the Ankole people, appears to be commoner in the wet highland country.

The population is divided into numerous tribes which may be separated anthropologically into Hamitic, Nilotic and Bantu types.

The customs of the various tribes differ enormously and domestic animals, cattle in particular, are intimately bound up with the sociological structure of most of them.

There are some 2 million cattle in the country and about 4 million sheep and goats. The native population is in the region of $3\frac{1}{2}$ million.

Reference to the annual report of the Medical Department of the Protectorate for 1934 shows that a total 981,155 patients were seen out of which 1,017 were cases of tuberculosis. This figure, of course, does not give a true picture of the incidence of the disease as the majority of cases of tuberculosis are never seen at Government Medical centres, especially in Ankole.

The actual incidence of the disease is difficult to assess. The only investigation in this connection was carried out in 1933 by Dr. Scott Brown , Medical Officer. He performed the Mantoux intradermal test on 50 natives in Ankole. They were divided into three groups.

The first group consisted of a random sample of 30 Bahima who were in a Rinderpest inoculation camp with their cattle. Of these, 23 or 76.6% were positive. In the section dealing with bovine tuberculosis in this area it

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will be seen that the percentage of cattle which gave a positive reaction to the tuberculin test was approximately the same.

The second group consisted of 15 patients in Mbarara hospital. They were not Bahima but Bairu or peasants who normally do not keep cattle but are pure agricultura--lists. Two or 13.3% showed positive reactions. One of the negative reactors was suffering from advanced pulmonary tuberculosis.

The third group consisted of 5 Bahima hospital attendants. In their childhood they were closely associated with cattle and lived the ordinary Bahima life in the kraals. They left the cattle and kraals as boys and went to school. Of these, 3 were positive and 2 negative.

My investigations were carried out at the Veterinary Laboratory at Entebbe with occasional visits to various districts as my official duties permitted.

Various maps and photographs are submitted with the text of this paper with the object of facilitating an understanding of the conditions and types of animals existing in Uganda, a country which is comparatively little known in Europe.

Although Uganda has only been administered some fifty odd years I venture to predict that tuberculosis of both men and animals will demand considerable attention in the future, when public health and sanitary services are better developed.

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PART II

TECHNIQUE USED IN THE BACTERIOLOGICAL INVESTIGATIONS.

It is rarely that one obtains a specimen of tuberculous material from which the organisms can be obtain--ed in pure culture without resorting to some method which will destroy contaminating bacteria.

This applies especially to bacteriological work in the tropics where the climatic conditions hasten putrefaction and encourage th e growth of any organisms that might be present.

Of the commoner substances used for this pur--pose there is antiformin, introduced by Uhlenhuth (1909). He used a 15 per cent solution of antiformin mixed with sputum which was allowed to stand for an hour after being thoroughly shaken. The liquid is centrifuged and the sediment washed twice in sterile water before being sown on to the medium. A. S. Griffith (1916) recommended a simpler method which dispensed with the centrifuge and consisted of sowing the material at intervals according to the rapidity of solution of the mucin in the sputum. Five per cent. solution of Potassium and Sodium hydrate and Sulphuric acid up to 10% are also used.

Wilcox (1934) working in the neighbouring territory of Tanganyika had great difficulty in removing contaminants from specimens of sputum, and especially mentions an organism resembling Aspergillus niger. He used a modification of Griffith's antiformin method and Petroff's method. In the latter he used a 4% caustic soda solution and incubated the mixture for half-an-hour at 37^{o}C., centri--fuged, neutralised the residue with a drop of Hydrochloric acid, and planted on a medium containing 1 : 10,000 Gentian Violet.

Herrold's (1931) egg-yolk agar was the medium chosen. Wilcox's results were not particularly encouraging as he only obtained 9 pure cultures out of 57 attempts to isolate the acid-fast bacilli from the sputum. In the tropics the air is laden with moulds and other spores, especially bacillus subtilis, and the greatest care has to be taken to prevent contamination whilst working with open tubes.

A large number of media has been used for the growth of Mycobacterium tuberculosae, but it is generally recognised that a basis of egg is essential for a satis--factory primary isolation.

Throughout these investigations I have used a modification of Lowenstein's medium (Cumming, W.M. and Foster, M.W., 1933) with and without glycerine, and Dorset's egg with and without glycerine.

Of these two I have found that in the vast majority of cases the modified Lowenstein's medium gave better and quicker growths and more clear-cut results, whether bovine or human strains were being dealt with. The method of preparation of this medium is as follows :-

1. Magnesium sulphate . . . . . 0.5 grammes.
   Potassium acid Phosphate, KH_2PO_4, 0.5 "
   Sodium dihydrogen citrate . . . 0.5 "
   Asparagin . . . . . 1.5 "
   Water . . . . . 500.0 c.c.
   Dissolve these salts in a flask over a flame.

2. Plain Egg.

   320 c.c. of the above solution;
   12 grammes Potatoe Flour (Groult's Fe'cule de Pomme-de-terre).

   Stir over a flame in a beaker until the mixture becomes a thick smooth paste. Autoclave at 15 lbs. pressure for 20 minutes. When cool add the yolks of two eggs, and 8 whole eggs. Mix well, tube and inspissate at 85°C., for 1 hour. Sterilise in a water-oven at 90°C., for ½ an hour on two successive days.

3. Glycerine Egg.

500 c.c. of the above solution;
30 c.c. Glycerine.

Dissolve and take 320 c.c. of the mixture and add 24 c.c. Glycerine, and 15 grammes Potatoe flour. Stir over a flame in a beaker till the mixture becomes a thick smooth paste. Autoclave at 15 lbs. pressure for 20 minutes. When cool add yolks of 2 eggs and 8 whole eggs. Mix well, tube and inspissate at 85°C., for 1 hour. Sterilise in a water-oven at 90°C., for ½ an hour on two successive days.

This glycerinated medium differs slightly from Cumming's original formula to suit local conditions. 15 grammes of potatoe flour are used instead of 12 grammes because in the humid atmosphere of Entebbe the glycerinated egg tended to be rather soft in consistency.

Almost all the specimens for cultural purposes came from a distance to the Laboratory. They consisted of specimens of sputum, pus, caseous glands, etc. They were dispatched from nearly every station in the Protectorate and in many cases took several days, and even up to a week, before they eventually arrived at Entebbe.

The transport arrangements in a young country like Uganda are not particularly rapid, and journeys of several days over anything up to 300 miles were quite unavoidable. The majority of specimens arrived in an advanced stage of putrefaction, and lids and corks of the containers were frequently dislodged by the pressure of the gases produced. Nevertheless it was the exception, rather than the rule, to fail to obtain a pure culture.

A. S. Griffith (1930) quotes Cornet (1904) to the effect that the tubercle bacillus is overwhelmed and destroyed by putrefactive and saprophytic organisms in a period ranging from a few days to ten months depending on experimental conditions.

In India, M. B. Soparkar (1917) produced experimental evidence to show that tubercle bacilli could be cultivated from decomposing sputum for 20 days, but no growth could be obtained after 26 days. The growth obtained after

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20 days consisted of about half-a-dozen colonies, while the control tube inoculated with fresh sputum showed colonies so thickly set as to form an almost continuous film.

It is evident that during putrefaction the number of tubercle bacilli decreases day by day. Kelser (1927) merely states : "In putrefying material they will remain viable for months." No evidence is given in support of this statement.

From my experience in these investigations the tubercle bacillus appears to be able to withstand decomposition under conditions pertaining in Uganda up to 7 days and probably longer. The average temperature during transit of the tuberculous material would be approximately 80^{o} - 85^{o} F.

ISOLATION FROM SPUTUM.

The technique carried out was that recommend--ed by Cumming, W.M. and Foster, M.W. (1933). The sputum on arrival at the Laboratory was immediately transferred to a sterile 3" x 1" tube containing a triangular iron loop just less in size than the internal diameter of the contain--er. These tubes, complete with the iron loops were kept ready sterilised for use. About one and a half times the amount of N/1. NaOH was added to the sputum which was then mixed until it was completely homogenised by twisting the iron loop round rapidly with the fore-finger and thumb. The specimen was then allowed to stand for 20 minutes up to an hour in the incubator at 37^{o} C. On one occasion it was left overnight, approximately 20 hours, and a culture was obtained.

The treated specimen is centrifuged for 20 minutes to half-an-hour at about 3,000 revolutions per

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minute. The supernatant fluid is then completely decanted, and the deposit roughly neutralised with N/1.HCl and seeded liberally with a large loop on to the surface of 6 tubes of the non-glycerinated egg medium. The inoculum was well rubbed into the surface of the medium.

ISOLATION FROM PUS, CASEOUS MATTER, ETC.

In cases where a cadaver could be opened in a sterile manner a small amount of tuberculous material was ground up with about 1 c.c., of Lemco broth in a sterile Griffith's tube. The medium was sown with two or three loop fulls of the supernatant fluid.

The Griffith's (1930) tube consists of a short stout test-tube ground at the bottom inside, and a pestle made of a glass rod ground at the extremity. This method of grinding up the caseous matter, etc., was found very much more satisfactory than merely transferring the tuberculous tissue directly on to the surface of the medium.

In cases where contaminating organisms were present the material was ground up with a little N/1.NaOH and incubated at 37° C., for ½ to 1 hour with frequent shaking, and allowed to stand for a minute or two until coarse particles had settled to the bottom. The supernatant fluid was then centrifuged, the deposit neutralised and sown on to non-glycerinated medium.

Owing to the risk of contamination in the tropics it is necessary to take considerable care in the handling of culture-tubes, etc. The wool plugs are flamed before withdrawal, and the mouth of the tube well flamed. After inoculation the mouth is again flamed and the plug held in forceps well lighted and pushed well down into the tube. The upper part of the tube is then well roasted in the bunsen before placing in the rack.

After cooling the culture-tubes are sealed off with plasticine through which a small hole is bored with a fine platinum needle. This procedure prevents evaporation of the medium without entirely excluding air from the tube, and has the same advantages as the screw-topped bottles recommended by J. E. McCartney (1933). These bottles are neater and possibly more satisfactory but were unobtainable in Uganda. Working in India, Soparkar (1916) plugged the culture-tubes with sublimated cotton-wool together with corking the tubes with paraffined corks in each of which a small hole had been bored. I have found that this simple technical detail with plasticine has made all the difference in obtaining satisfactory growths of the tubercle bacilli.

The inoculated tubes are numbered, and placed in small stiff paper cartons which are put in special copper racks holding a dozen different cultures. In the incubator at 37° C., they are examined once a week for 3 months, after which, if no growth occurs, they are discarded.

In many cases, especially the sheep and goat strains, guinea-pigs were inoculated in addition to the direct cultures, and in the majority of instances growths were obtained.

In a number of cases, especially from sheep, goats and cattle, acid-fast bacilli were not evident in direct films from the lesions, but nevertheless cultures were obtained. In this connection it might be well to refer to a recent paper by E. M. Holmes (1935), who advocates cultural tests in all cases of even remotely suspected tuberculous material. She supports her contention by report--ing 53 positive cultures from the first 98 " negative " sputum specimens examined. The basis of the Jensen's medium employed by her is similar in many respects to that used in Uganda.

TYPING OF STRAINS OF MYCOBACTERIUM TUBERCULOSAE IN UGANDA.

The criteria of type in use in this investigation are the character of growth on the glycerine egg medium compared with non-glycerinated medium, and the virulence for the rabbit.

All primary cultures were made on non-glycerinated medium, and cultural characteristics were studied after sub-culture on a series of glycerinated and non-glycerinated egg media. If the results were not clear-cut further sub-cultures were made and rabbits inoculated. In a few cases there was little differentiation in the early subculture, but after one or two generations the character of the strain became quite definite. As has been mentioned previously, the modified Lowenstein's medium gave a much clearer differentiation than Dorset's egg in the majority of cases.

Whilst it was not possible, owing to the number of rabbits required, to test all the eugonic strains on these animals, nevertheless a considerable number were done as a check against the growth characters. In no instance, except one, has the type, as decided by rabbit virulence, been other than would have been expected from cultural characteristics. The exception was a partially dysgonic strain isolated from a specimen of human sputum, which proved to be non-virulent for the rabbit, the details of which will be given under a separate section dealing with the " typing " results obtained in human patients.

All dysgonic strains were inoculated into rabbits. The dose employed in rabbit virulence tests with all strains was 0.01 mg., intravenously, and/or 10 mg., or less intramuscularly.

A. S. Griffith (1930) recommends these doses (for

for differentiation purposes, and says : "If the intravenous method is used the dose of culture should not exceed 0.01 mg. because larger doses of human bacilli may give rise to an acute tuberculosis which is difficult to distinguish from that set up by bovine bacilli. For subcutaneous inoculation the best dose is 10 mg."

From the Royal Commission on Tuberculosis, Part II, Appendix Vol. I, p. 437, it may be gathered that rabbits inoculated intravenously with 0.1 mg., of culture invariably died of tuberculosis within 34 days. The average period was 21 days. In Uganda the cultures were weighed moist on a Bunge's aperiodical Analytical Balance, the readings being taken directly from the micro-scale in milli--grammes. The scale was previously controlled with platinum weights.

The small doses for intravenous inoculation were obtained by the usual method of dilutions with sterile normal saline, the requisite dose being contained in 1 c.c. Only young vigorously growing cultures from 10 - 28 days old were used for animal inoculations.

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PART III

TUBERCULOSIS IN CATTLE

(A). REVIEW OF THE LITERATURE DEALING WITH BOVINE TUBERCULOSIS IN THE TROPICS.

Tuberculosis as a disease in cattle has not, up to the present time, attracted much attention in Tropical Africa. Amongst the indigenous cattle in the Tropics as a whole it is considered to be infrequent.

Veterinary activities have been concerned with the more dramatic and rapidly fatal diseases of domestic animals, and Tuberculosis has been overshadowed by such epizootics as Rinderpest, Pleuro-Pneumonia, East Coast Fever, Anthrax, etc., which from time immemorial have ravaged the flocks and herds in tropical countries.

In recent years, owing to closer administra--tion and the success obtained in dealing with these major epizootic diseases, more attention has been devoted to tuberculosis. It has, however, only recently been recognised as existing at all in many countries.

The general apathy of the native cattle-owners to all diseases, especially those which are not responsible for heavy immediate losses, renders detection of tuberculosis difficult.

Meat inspection in Tropical Africa is a very recent innovation and by no means a universal custom, and the vast majority of meat consumed by natives is uninspected even at the present time.

In Tropical Africa and Asia almost all the indigenous cattle are of the Zebu type (Bos Indicus) ,

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although, as will be pointed out later, there are areas which are characterised by non-Zebu animals.

INDIA.

In India, up till quite recently, tuberculosis has been considered a rare disease in the indigenous cattle. Mitter (1910) reported four cases of bovine tuberculosis in Calcutta. Three were in Zebu cattle and one in a Buffalo. He records that during the previous twelve years there were 45 fatal cases of tuberculosis in cattle at the hospital of the Bengal Veterinary College. Almost without exception these occurred in Zebu cows.

Liston and Soparkar (1917) state : " accord--ing to the opinion of a large number of observers bovine tuberculosis is of rare occurrence in India " . This condition of affairs has been attributed to the open-air existence of Indian cattle as compared with cattle kept in Europe, an hypothesis which is frequently met with in the literature on bovine tuberculosis in the tropics and which seems to be a popular explanation for the comparative rarity of the disease.

As will be pointed out later, this would certainly not apply in Uganda or in fact in most parts of Tropical Africa, since the vast majority of cattle are never housed.

The above authors (Liston and Soparkar 1917) carried out experiments with a view to ascertaining whether the local Indian breeds are more resistant to tuberculosis than their European prototypes.

Twelve buffalo and twelve cow-calves from four to eight months old were inoculated subcutaneously in front of the shoulder with a virulent strain of Mycobacter--ium tuberculosae obtained from Dr. Eastwood which was used

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in the experiments of the English Royal Commission on Tuberculosis.

The doses used were 50 mg. and 10 mg. In their protocols the authors record the changes occurring at the seat of inoculation, the condition, body weight and daily temperatures throughout the experiment. The results of the post-mortem examinations are also given and elaborate figures are drawn to illustrate the distribution of the lesions in Indian calves as compared with those described in the case of English calves experimented on under similar conditions, as detailed in the reports of the English Royal Commission on Tuberculosis.

The results of the experiment indicated that the comparative infrequency of the disease among cattle in India is due to a natural resistance rather than to any method of housing or keeping cattle in India as compared with England.

The question of the comparative resistance to tuberculosis exhibited by Zebu cattle will be considered in a later chapter.

Taylor (1918) carried out an enquiry as to the prevalence of bovine tuberculosis in the Punjab from August 1915 to March 1916, during which period 3,276 animals were admitted for slaughter at Ferozepore. Examination of all animals was performed prior to slaughter and 575 or 17.8% were rejected as not likely to be fit for human consumption on account of innutrition, disease or old age. It is probable that a good many of these cast animals were suffering from chronic tuberculosis. Of the remaining selected animals 95 or 3.5% proved to be tuberculous. In 60 of these cases tubercle bacilli were demonstrable in the lesions on microscopic examination. The lesions were mainly localised, and the bronchial and mediastinal glands were

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most commonly affected.

During the year 1916 - 1917 (1st. April to 31st. March), 4,610 animals were brought for slaughter. Of these 821 were rejected as unfit, and of the remaining animals 125 or 3.3% were found infected.

The question of bovine tuberculosis was discussed at the first meeting of Veterinary Officers in India (1919) held at Lahore. Olver pointed out that no real scientific enquiry had yet been carried out in India upon the incidence of tuberculosis in cattle. At Cawnpore 3 per cent of the cattle at the slaughter houses were found to be infected. Lt.-Colonel A. Smith stated that about one case a year during the past 23 years had occurred in Calcutta. Major K. Hewlett said that no evidence of tuber--culosis had been found in the Bombay slaughter houses. Other speakers pointed out that tuberculosis was absent or very infrequent in Madras, Assam and Bihar and Orissa. G. Taylor referred to the large number of cases found in the slaughter houses at Ferozepore and Simla, and gave his opinion that tuberculosis was fairly prevalent in Northern India. Sowerby (1923) reported a case of tuberculosis in a seven-year-old cow in the Bombay Presidency. Lesions were present in the lungs, liver and udder.

Liston and Soparkar (1924) isolated 9 strains from various animals at the Bombay Zoological Gardens eight of which resembled the bovine virus. One strain was indis--tinguishable from the human type - this from a Binturong. The others were from antelope and a Llama. Naik (1932) reported a case of generalised tuberculosis in an Indian buffalo.

In Ceylon, 1934, there were over 40,000 bovine carcases inspected of which only one was found to be tuber--culous.

TROPICAL AFRICA.

As far as Africa is concerned the general impression is that the disease is rare among the indigenous cattle, thus accounts of sporadic individual cases are found recorded in the literature.

West Africa.

Most of the cases have been reported from the French possessions. Curasson (1919) reported that he had met cases of tuberculosis of the udder in native cattle at Dakar, the bacilli being of the human type. No bacterio--logical evidence supports this view.

In Dahomey, Curasson (1920) reports a tuberculosis morbidity rate of about 33 per cent in a race of cattle known as Lagunes. These cattle appear to be an isolated breed and are said to be badly stalled. The report is interesting in view of the experience in Uganda with the Ankole cattle.

Teppaz (1922) records a case of tuberculosis in a Zebu animal at the slaughter house at Dakar, the first example of bovine infection seen by him in many thousands of cattle he examined both at Dakar and Saint Louis. He states that the bacilli were probably of human origin but produces no evidence for this unorthodox view.

Nainsouta (1922 and 1923) records two further cases of tuberculosis in Zebus at the Dakar abattoirs. Tubercular lesions ranging in size from a nut up to that of a man's fist were found in the lungs. The bronchial and mediastinal glands were enlarged and tuberculous.

Teppaz (1923) reported another case from Dakar, the fourth to be discovered. The animal was a Zebu and the lesions were confined to the lungs. A guinea-pig which was inoculated from this case died on the 26th. day

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from generalised tuberculosis. A rabbit was also inoculated and apparently did not become infected, but it does not appear to have been killed and examined post-mortem.

Teppaz (1923) further records that tubercu--losis whilst not absent in French West Africa is rare. In an abattoir killing 20-30 animals a day he only found 6 cases in three years.

Curasson (1928) amplifies the findings of Teppaz in French West Africa. He believes that tuberculosis occurs more frequently than has been suspected. In 1925 there were 26 cases found among 4,205 Zebus slaughtered at Bamako. In 1934, in French West Africa at Bamako, out of 7,573 cattle slaughtered there were 49 cases of tuberculosis, of which 22 were generalised. At Dakar 5 cases were discov--ered out of a total of 12,818 carcases inspected.

In the British colonies in West Africa tuber--culosis in cattle is rare. Hall (1930) recorded the first case in Northern Nigeria. This animal died and on post-mortem examination proved to be an acute case of pulmonary tuberculosis showing perlsucht lesions on the pleurae, numerous tubercles in the parenchyma of the lungs, and involvement of the bronchial and mediastinal glands. The organism was isolated in culture and proved to be a typical dysgonic bovine type. The disease has been reported on several occasions in S. Nigeria (1930).

In 1931 the cattle at the laboratory at Vom were tuberculin tested. Seventeen reacted and of these seven showed lesions on post-mortem.

In 1934 six cases of tuberculosis were discov--ered at the slaughter houses in N. Nigeria.

On the Gold Coast, bovine tuberculosis is uncommon. No cases were reported in the years 1930 - 34 inclusive.

In the Cameroons, Zeemann (1913) reported the absence of the disease in the indigenous cattle.

Manley (1929) carried out tuberculin tests on cattle owned by a German Company in the British Camer--oons. The cattle were cross-bred Zebu-native or Algauer--native and pure-bred Algauer stock. Of the 56 animals tested 14 reacted of which 10 were cross-bred cows. The disease was apparently introduced from Germany by the imported pure-bred stock.

In the Belgian Congo, Mouchet (1913) stated that bovine tuberculosis did not exist in the area of Leopoldville.

Egypt.

Tuberculosis exists in the cattle. Littlewood (1920) reported 3,524 cases detected almost entirely in the Cairo and Alexandria abattoirs, which was 5.21% of the animals slaughtered. Of 2,210 cattle belonging to the Domains administration which were tested with tuberculin 963 or 43.5% reacted.

Sudan.

Tuberculosis appears to be extremely rare. One case was reported in 1932 from the Bahr-el-Ghazal Pro--vince. The Director of Veterinary Services sums up the position as follows : " In consideration of the number of cattle slaughtered in controlled centres for food and of the fact that several hundred cattle are annually examined post-mortem in the Veterinary laboratories at Khartoum and Malakal, the disease must be very uncommon." In the report of the Veterinary Services, Egypt, 1916 and 1917 (Littlewood), there is mention of one case of tuberculosis in a bull from the White Nile Province, the first case from that locality. Over the previous five years eight cases occurred and all

(emanated

emanated from Kordofan Province. These were in Soudanese cattle slaughtered in Egypt.

As far back as 1912 Archibald reported a suspected case of tuberculosis in a camel in the Sudan but no cultural tests or animal inoculations were performed.

Kenya.

Tuberculosis is rarely mentioned in the Annual Reports of the Veterinary Department. In 1933 two cases were diagnosed in Suk cattle. This is of interest as the Suk country borders on Karamoja in Uganda from where several cases have recently been discovered in the Kampala abattoir.

Tanganyika Territory.

In the Annual Report of the Veterinary Depart--ment, McCall (1929) records that only four cases of tuberculosis in Zebu cattle in the territory are on record. Further reports give the following information :-

1930. "Extremely rare" ;

1931. "Extremely few cases of this disease reported" ;

1932. Of 15,423 carcases inspected there were 2 cases which occurred at Iringa.

1933. There were 14,904 carcases inspected of which 9 were tuberculous.

The observation is made that the bovine disease is extremely rare in the drier parts of the country but not so rare in the moister parts. In this connection the position in Uganda, as will be explained later, is rather the reverse. Most of the bovine tuberculosis occurs in the drier districts.

Cornell (1934) tested with tuberculin 441 cattle (Zebu) belonging to the Wachagga tribe on the slopes of Kilimanjaro. There were eight reactors but no lesions were discovered in four of these which were slaugh--tered. Of 13 doubtful reactors one was slaughtered but no

(lesions

lesions were present. The Wachagga keep their cattle in their huts where they are hand-fed, whilst the incidence of tuberculosis both pulmonary and surgical is high among these people.

Hornby (1934) reviewed the position with regard to bovine tuberculosis in Tropical Africa and Tanganyika Territory in particular, and points out that a proportion of the total cases reported are connected in some way with imported European stock. He states : "A reasonable view seems to be that native races of cattle, particularly the Zebu, are more resistant to tubercle infection than are cattle of European race, and that the more open-air life led by the majority of native cattle further contributes to a low incidence of tuberculosis." Before accepting such an hypothesis much more concrete evidence would appear to be desirable.

Nyasaland.

Tuberculosis in cattle seems to be very rare. There were two cases reported in 1926, and one suspected case in 1934.

Northern Rhodesia.

The disease appears to be associated with imported cattle. Purchase (1929) found 90 reactors out of 444 cattle in an old-established herd in the Fort Jameson district. The animals were chiefly Hereford-native and shorthorn-native crosses. The highest number of reactors occurred among the young stock, some 26 per cent.

In Southern Rhodesia and the Union of South Africa there is so much imported European stock that it is almost impossible to get accurate figures for the purely native breeds.

(B) BOVINE TUBERCULOSIS IN UGANDA.

The cattle in Uganda, which number approximate--ly 2 million head, are divisible into three groups, (vide map). Firstly, the Zebu group which is the predominating race of cattle in Equatorial Africa. Their numbers in Uganda easily surpass those of the remaining two groups. They occupy all the Eastern and most of the Northern Provinces.

The second group consists of the Ankole cattle. These animals are characterised by enormous horns. They have no hump and are much longer in the leg than the Zebu animals. They exist as a highly characteristic group of cattle amidst the usual tropical African short-horned, humped animals. Their origin is unknown, but the generally accepted theory is that they came from the Galla country of Abyssinia and were brought South and West with their hamitic owners - the Bahima. The Ankole cattle occupy Ankole proper, and the Western part of Buganda Province, besides small areas in Tanganyika and the Belgian Congo.

There is situated between the Ankole and the Zebu cattle a third group of cattle which is intermediate between the long-horned hamitic type and the short-horned Zebu. These cattle occupy most of Buganda Province, most of Toro and Bunyoro, and also Kigezi in the West.

HISTORY AND INCIDENCE.

Almost the whole of the bovine tuberculosis exists in the Ankole cattle and the incidence, as will be illustrated later, is extremely high. In the Zebu and inter--mediate types tuberculosis, whilst not rare, is certainly infrequent.

The first record of bovine tuberculosis in

(Uganda

Uganda was in 1917 when lesions were discovered in some Ankole cattle sent to the Kabete Laboratory in Kenya for the manufacture of Anti-Rinderpest serum.

In 1918, the late Mr. E. Hutchins M.R.C.V.S., the Chief Veterinary Officer, in a pamphlet on Animal Diseases under the heading Tuberculosis records that : "Only one case has hitherto been met with amongst cattle in Uganda."

In the Annual Reports of the Veterinary Department, 1919 to 1928 inclusive, tuberculosis is not mentioned as occurring in the Protectorate. In 1929, seven cases of tuberculosis, all in Ankole cattle, are reported and the following observation made : "The number of cases exceeds those reported in previous years but this cannot be interpreted as any proof of an increase in the incidence of the disease. Circumstances have allowed a greater number of carcases of Ankole cattle to be examined."

In 1930 thirteen cases were recorded. The year 1931 showed the first marked increase in the number of cases discovered, as forty-eight, of which 21 were generalised, were discovered in 277 carcases inspected at Mbarara.

Further investigations were carried out in 1932 when no less than 140 cases were observed in 1,654 Ankole cattle, and 3 cases out of 2,600 Zebu carcases. It should be explained that in that year, owing to successful disease control, the trade in slaughter cattle especially from the Eastern Province (Zebu area) greatly increased.

In 1933 the figures were as follows :-

Ankole cattle :- 2,874 carcases examined, 359 or 12,5% showed tuberculous lesions.

Zebu cattle :- 4,458 carcases examined, 31 or 0.7% showed tuberculous lesions.

During that year the opportunity was taken to examine 131

(Ankole

Ankole cattle which had died of Rinderpest. Of these 51.1% showed visible tuberculous lesions.

In 1934, at one market near Kampala, tubercu-losis was observed in 50 out of 2,067 Zebu animals or 2.41%, whilst out of 685 Ankole animals no less than 233 or 34% contained lesions.

The post-mortem statistics, including 1935, are tabulated below.

TABLE SHOWING INCIDENCE OF TUBERCULOSIS IN UGANDA CATTLE AS SEEN POST-MORTEM.

YEAR	No. of Carcases examined	Type of Cattle	No. of cases of T.B.	Percentage INCIDENCE:
1921.	623	Ankole and Intermediate.	0.	0.
1922.	228.	-do-	0.	0.
1923.	152.	-do-	0.	0.
1924.	488.	-do-	0.	0.
1925.	709.	-do-	0.	0.
1926.	373.	-do-	0.	0.
1927.	171.	-do-	0.	0.
1928.	191.	-do-	0.	0.
1929.	Not men-tioned.	-do-	7.	-
1930.	-do-	-do-	13.	-
1931.	277.	Ankole.	48.	17.3
1932.	1,654.	Ankole.	140.	8.4
	2,600.	Zebu.	3.	0.1
1933.	2,874.	Ankole.	359.	12.5
	4,458.	Zebu.	31.	0.7
1934.	685.	Ankole.	233.	34.0
	2,067.	Zebu.	50.	2.4
	4,148.	Zebu (Karamoja)	93.	2.24
1935.	464.	Ankole.	192.	41.4
	370.	Zebu.	1.	0.3
	1,334.	Zebu.	13.	0.97
	4,154.	Zebu.(Karamoja)	15.	0.36

At one market near Kampala, in 1935, the lesions of tuberculosis were found to be according to the table below.

TABLE SHOWING DISTRIBUTION OF TUBERCULOUS LESIONS.

Number of Cattle	Type of Cattle	Total No. Tubercu--lous	Distribution of lesions		
			Thoracic Cavity	Abdomi--nal Cavity	Generalis--ed infection
464.	Ankole.	192. (41.4%)	96. (50%)	75. (39%)	21. (11%)
1,334.	Zebu.	13. (0.97%)	12. (92%)	1. (8%)	- -

INCIDENCE OF TUBERCULOSIS IN CATTLE IN UGANDA AS DEMONSTRATED BY THE TUBERCULIN TEST.

All the tests were carried out by the double intradermal method and the technique employed was that advocated by the Medical Research Council (1925).

Owing to the frequency of conjunctivitis and other inflammatory conditions of the eye the ophthalmic test is unreliable in Uganda, whilst the normal fluctuations in the temperatures of healthy cattle in the tropics nullifies the subcutaneous method.

The number of tests carried out in Uganda is not large, some 800 approximately.

None of the cattle tested were housed, and all lived entirely in the open air.

TABLE SHOWING RESULTS OF TUBERCULIN TESTS.

Number Tested	Sex	Type of Cattle	Number Positive	Remarks and observations
5.	Bulls.	Ankole.	1.	Killed and found tuberculous.
2.	Bulls.	Intermediate (Kigezi)	-	-
19.	Bulls.	-do-	3.	All 3 killed and found tubercu--lous.
4.	Bulls.	Ankole.	2.	1 killed and found tuberculous.
90.	Mixed.	Mixed.	7.	3 killed and found tuberculous.
42.	Mixed.	Ankole.	19. (45%)	No Post-Mortem carried out.
44.	Mixed.	Ankole.	9. (20%)	On these two herds 14 post-mortems were carried out on the 17 reactors and lesions were found in 13.
50.	Mixed.	Ankole.	8. (16%)	
15.	Mixed.	Mixed Ankole & Intermediate.	3.	No P-M's carried out.
9.	Young Bulls.	Ankole.	1.	-do-
6.	Bulls.	Zebu.	0.	-do-
1.	Old Cow.	Ankole.	1.	Killed and found tuberculous.
4.	Bulls.	Ankole.	2.	No P-M's carried out.
4.	Bulls.	Zebu.	0.	-do-
6.	Young Bulls.	Ankole.	5.	-do-
205.	Mixed.	Ankole.	157. (76.6%)	-do-
121.	Mixed.	Intermediate. (Kigezi)	6. (5.2%)	-do-
12.	Bullocks.	Zebu.	0.	All eventually examined post--mortem and no lesions present.
	(N.B. These cattle were housed with tuberculous natives in Bugishu.)			
158.	Mixed.	Zebu.	1. (0.6%)	No post-mortems carried out.

GENERAL DISCUSSION AND CONSIDERATION OF THE RESULTS.

A consideration of the slaughter house returns and the tuberculin tests reveals a strikingly high incidence of tuberculosis in the Ankole stock, and a comparatively low morbidity rate in the Zebu and Intermediate types.

Except in the case of a few individual tribes native cattle are never housed. It is, however, the almost universal custom to nurse a sick animal in the hut of the owner, whilst the calves usually share the human dwelling places.

In Ankole the cattle roam over short grass down-like country and at night they are put into a kraal or round enclosure of thorn bushes.

The rainfall in Ankole is in the region of 30 inches per annum with dry seasons of approximately three months each. It is the custom to burn off the grass at the end of each dry period in order to provide fresh grazing when the rains commence.

In order to ward off biting flies and mosqui--toes, a smudge fire of dried cow dung is lit just before sundown, and the cattle pack themselves head to head round these fires apparently relishing the smoke.

The close contact and the coughing due to the smoke may well facilitate the spread of tuberculous infec--tion from one beast to another.

The disease is well known by the Bahima cattle owners. They are pastoral hamitic stock whose staple diet is milk and blood of their cattle. In the Luhima language the disease is called " Ruhosho " and according to tribal legend it has always been present both in the cattle and in man. There seems to be no information as to when and where the disease originated.

No European-bred stock has ever crossed the tribal boundary. In fact European cattle, to all intents and purposes, are non-existent in Uganda except on one or two Government Stock Farms.

The presence of East Coast Fever and other tick-borne diseases definitely prevents any European cattle from surviving for more than a few weeks, except under special conditions.

The interesting feature is the high incidence of tuberculosis in this one isolated breed of Ankole cattle in Central Africa.

The whole history of the Bahima people and their cattle is uncertain and bound up with complicated anthropological questions. It may well be possible that tuberculosis came with these people in their legendary trek from the Hamitic area of North East Africa.

On the evidence accumulated one naturally assumes that Ankole cattle appear to be more susceptible to tuberculosis infection than the truly indigenous Zebu cattle of Central and East Africa. Experiments designed to investi--gate this question have been carried out and will be discussed later.

OBSERVATIONS ON THE DISEASE, NATURE OF LESIONS, NATIVE TREATMENT, ETC.

From the figures given it would appear that bovine tuberculosis has increased considerably in Uganda during recent years. Owing to the lack of any control measures and the primitive methods of husbandry, there can be no doubt that the disease is on the increase for the simple reason that there is nothing to prevent it.

The figures given in this paper, however,

(cannot

cannot be considered as significant of a serious increase in the incidence of the disease as the general facilities for inspection, and the number of cattle slaughtered, have increased enormously during the past ten years. In a young country the usual course of development is bound to reveal the situation as time goes on.

It is uncommon to find generalised cases of bovine tuberculosis in Uganda, though it is probable that these occur at times in the native kraals and are not reported. In the majority of cases the lesions are found in the mediastinal and bronchial glands and lungs with no evidence of intestinal infection. Tuberculous foci are, however, not rare in the abdominal cavity.

It would seem that the main portal of entry is through the respiratory tract. The custom already referred to of crowding round the smudge fire in the kraal would facilitate this mode of infection. It is evident from the localised infection in the glands that the Uganda cattle have a considerable resistance to the disease and are not, in Cobbet's words, " virgin soil " for infection with tuberculosis.

There is no doubt that tuberculosis has been recognised by the natives of Ankole for many years. It is extremely rare to find cases showing the classical grape--like clusters of tubercles or perlsucht lesions on the pleurae. Only one case was discovered out of several hundred tuberculous cattle examined in Kampala abattoir in 1934.

Although tuberculosis is known to the Bahima people of Ankole, the cattle-owning natives in the Nilotic areas of Uganda do not appear to recognise the condition.

One of the commonest ways of treating the

(disease

disease in Ankole is by branding the chest-wall with hot irons (Fig.). Various vegetable infusions are also prescribed by the tribal " cattle doctors " in the hope of effecting a cure of the disease.

STRAINS OF MYCOBACTERIUM TUBERCULOSAE OCCURRING IN CATTLE IN UGANDA.

No work has been carried out in connection with the type of organism causing tuberculosis in Uganda cattle or indeed in Eastern Africa.

As mentioned previously, the human type of organism has on several occasions been incriminated without any bacteriological proof by various French workers in West Africa.

A number of strains have been isolated from cases of bovine tuberculosis in Uganda with a view to studying their cultural characters and their pathogenicity to rabbits. These are the generally accepted criteria of proof of a typical bovine type of Mycobacterium Tuberculosae as studied in Europe.

The results are set forth in tabular form to facilitate reference. It will be seen that so far as can be determined from the number of strains isolated and studied, bovine tuberculosis in Uganda is caused by the orthodox dysgonic bovine type of bacillus.

TABLE SHOWING STRAINS OF MYCOBACTERIUM TUBERCULOSAE ISOLATED FROM SPONTANEOUS INFECTIONS IN CATTLE IN UGANDA.

(N.B.: S.C. = Subcutaneous; I.M. = Intramuscular; I.V. = Intravenous.)

TYPE OF CATTLE	CULTURAL CHARACTERS	ANIMAL INOCULATIONS				AUTOPSY
		Animal	Inoculum	Killed or died	Period of survival in days	
1. Ankole (Wandegeya A)	Dysgonic, not improved by Glycerine.	G.-pig.	Caseous gland S.C.	Killed.	67.	Advanced generalised T.B.
		Rabbit.	10 mg. culture I.M.	Died.	78.	Severe generalised T.B. Lungs full of tubercles. Kidneys full of raised tubercles. Loss in weight 540 gms.
		G.-pig.	2 mg. culture S.C.	Died.	60.	Generalised T.B.
2. Ankole Calf, generalised T.B.	Dysgonic, not improved by Glycerine.	Rabbit.	7 mg. culture I.M.	Died.	84.	T.B. lungs, raised tubercles. Kidneys, abscess at site of inoculation.
3. Ankole.	Dysgonic, not improved by Glycerine.	G.-pig.	Caseous gland S.C.	Killed.	74.	Advanced generalised T.B.
		Rabbit.	10 mg. culture I.M.	Died.	69.	T.B. lungs, kidneys and spleen, local abscess.
4. Ankole.	Dysgonic, not improved by Glycerine.	Rabbit.	5 mg. culture I.M.	Died.	34.	T.B. lungs and kidneys. Local abscess.
5. Zebu. (Karamoja)	Dysgonic, not improved by Glycerine.	G.-pig.	Caseous gland S.C.	Died.	87.	Severe generalised T.B.
		G.-pig.	-do-	Died.	142.	Severe generalised T.B.
		Rabbit.	3 mg. culture I.M.	Died.	81.	Acute T.B. of lungs, kidneys and spleen. Local abscess.
6. Zebu (Teso).	Dysgonic, not improved by Glycerine.	G.-pig.	Caseous gland S.C.	Died.	105.	Generalised T.B.
		G.-pig.	-do-	Died.	133.	Generalised T.B.
		Rabbit.	10 mg. culture I.M.	Died.	60.	T.B. lungs, kidneys. Local abscess.
7. Intermediate. (Kigezi).	Dysgonic, not improved by Glycerine.	G.-pig.	Caseous gland S.C.	Died.	111.	Generalised T.B.
		G.-pig.	-do-	Killed.	113.	Generalised T.B.
		Rabbit.	3 mg. culture I.M.	Died.	72.	T.B. lungs, kidneys and local abscess.
8. Ankole.	Dysgonic, not improved by Glycerine.	G.-pig.	Caseous gland S.C.	Died.	51.	Generalised T.B.
		Rabbit.	0.01 mg. culture I.V.	Died.	24.	Acute generalised miliary T.B.
9. Zebu, (Karamoja).	Dysgonic, not improved by Glycerine.	G.-pig.	Caseous gland S.C.	Killed.	170.	All glands. Spleen enlarged and tuberculous. Few tubercles in lungs.
		Rabbit.	-do-	Died.	116.	Local abscess. T.B. kidneys, lungs and spleen.
		Rabbit.	3 mg. culture I.M.	Died.	50.	T.B. kidneys, lungs and local abscess.

Continued.

Continued.

TYPE OF CATTLE.	CULTURAL CHARACTERS.	ANIMAL INOCULATIONS				AUTOPSY.
		Animal.	Inoculum.	Killed or died.	Period of survival in days.	
10. Zebu, (Karamoja).	Dysgonic, not improved by Glycerine.	Rabbit.	0.01 mg. culture I.V.	Died.	19.	Acute generalised miliary T.B.
11. Ankole.	Dysgonic, not improved by Glycerine.	G.-pig.	Caseous gland S.C.	Died.	80.	Generalised T.B.
		G.-pig.	-do-	Died.	91.	Generalised T.B.
		Rabbit.	0.01 mg. culture I.V.	Died.	27.	Acute generalised miliary T.B.
12. Ankole.	Dysgonic, not improved by Glycerine.	G.-pig.	Caseous gland S.C.	Killed.	94.	Advanced generalised T.B.
		Rabbit.	0.01 mg. culture I.V.	Died.	33.	Acute generalised miliary T.B.
13. Ankole.	Dysgonic, not improved by Glycerine.	Rabbit.	0.01 mg. culture.	Died.	24.	Acute generalised miliary T.B.
14. Ankole.	Dysgonic, not improved by Glycerine.	Rabbit.	-do-	Died.	25.	Acute generalised miliary T.B.
15. Ankole.	Dysgonic, not improved by Glycerine.	G.-pig.	Caseous gland S.C.	Died.	139.	Generalised T.B.
		Rabbit.	0.01 mg. culture I.V.	Died.	58.	Acute generalised miliary T.B.
16. Ankole.	Dysgonic, not improved by Glycerine.	G.-pig.	Caseous gland S.C.	Died.	92.	Generalised T.B.
		Rabbit.	0.01 mg. culture I.V.	Died.	34.	Acute generalised miliary T.B.
17. Ankole.	Dysgonic, not improved by Glycerine.	Rabbit.	-do-	Died.	21.	Acute generalised miliary T.B.
18. Zebu, (Lango).	Dysgonic, not improved by Glycerine.	G.-pig.	1 mg. culture S.C.	Died.		
		Rabbit.	7 mg. culture I.M.	Died.		
19. Zebu, (Lango).	Dysgonic, not improved by Glycerine.	G.-pig.	1 mg. culture S.C.	Died.	27.	Generalised T.B.
		Rabbit.	7 mg. culture I.M.	Died.	131.	Advanced T.B. lungs, kidneys and spleen.
20. Ankole.	Dysgonic, not improved by Glycerine.	Rabbit.	0.01 mg. I.V.	Died.	31.	Acute generalised miliary T.B.
21. Zebu, (Karamoja).	Dysgonic, not improved by Glycerine.	Rabbit.	0.01 mg. I.V.	Died.	41.	Acute generalised miliary T.B.
22. Zebu, (Karamoja).	Dysgonic, not improved by Glycerine.	Rabbit.	0.01 mg. I.V.	Died.	24.	Severe generalised miliary T.B.

(C) THE RELATIVE SUSCEPTIBILITY OF ANKOLE AND ZEBU CATTLE TO TUBERCULOSIS.

It is generally accepted that tuberculosis is an uncommon disease in the Zebu cattle of India and tropical Africa when compared with the incidence in European breeds.

In Uganda it has been pointed out that tuber--culosis is frequent in the Ankole cattle and rare in the Zebu animals; thus in 1933, out of 2874 Ankole carcases 12.5% were tuberculous, whilst the number of Zebu carcases which showed lesions was only 31 out of 4,458 or 0.7%.

In 1934 the figures are even more striking, as out of 685 Ankole animals there were 34% showing tuber--culous lesions, whilst in 2,067 Zebus only 2.41% were tuberculous. Recently I had the opportunity of tuberculin testing a number of cattle in Ankole. One herd of 105 animals belonging to Chief Kihimba showed a positive reaction rate of 64.8%, whilst another herd belonging to a Muhima named Kagushyo gave reactions in no less than 89 animals out of 100 tested. It should be pointed out that these herds were in no way selected but were typical of the area.

During the same tour I moved out of the Ankole area into Kigezi where the cattle are of the intermediate type and the results of the tests revealed 6 reactors out of 115 cattle.

I have not had the opportunity of testing any large number of Zebu cattle in Uganda, but positive reactions were ~~nil~~ one in ~~22~~ 180 which were tested.

Cornell's (1934) figures from Tanganyika, referred to earlier in this paper, demonstrate the paucity of reactors in Zebu cattle, whilst the Uganda slaughter

(house

house returns also provide valuable data in this respect.

The explanation that the open-air environment is responsible for the low tuberculosis morbidity rate in cattle in the tropics, can be dismissed immediately on the Uganda observations.

In this country there are two widely divergent types of cattle with an intermediate group. None of these cattle, except very occasionally, are ever housed. They live entirely in the open-air yet tuberculosis is extremely common in one type and very rare in the other two.

Tuberculosis does occur in the Zebu animals in Uganda yet there is no indication that it is extending. Is this condition of affairs due to a specific resistance on the part of the Zebu cattle as compared with the Ankole type, or is it merely due to the fact that tuberculosis has not become established in the Zebu areas ? The origin of the disease in cattle in Uganda is unknown. For all practical purposes European cattle have not been introduced into Uganda at all, so that infection from that source can be discounted.

In this connection it is interesting to remember that the Zebu cattle are indigenous whilst the Ankole cattle and their Hamitic owners, according to Driberg (1930), are of fairly recent introduction, about the Sixteenth century.

The question of the Zebus' specific resistance to tuberculosis has been investigated in India and compari--sons made with inoculation results in European breeds.

In Uganda, however, the question of comparative susceptibility lies between two native types of cattle, but the Indian work has a direct bearing on these investigations and will therefore be discussed.

Liston and Soparkar (1917),referred to earlier in this paper, carried out experiments with a view

(to

to determine the susceptibility of Indian cattle to tuber--culosis. They used a known virulent strain of Mycobacterium tuberculosae obtained from Dr. Eastwood, and inoculated 12 cow calves and 12 buffalo calves. In each of these two lots of animals, half received 50 mg. of culture and half 10 mg. of culture subcutaneously.

The authors summarise their results as follows :-

" While the experiments of the Royal Commission on Tuberculosis show that, with rare exceptions (1 out of 35), all English calves died of acute tuberculosis when inoculated with 50 mgms. of a culture of bovine tubercle bacillus, our experiments prove that at least 50 per cent. (6 out of 12) of Indian calves, whether they be buffalo or cow calves, live for many days after a similar dose of culture of the bovine bacillus, and when killed show only retrogressive or healing tuberculous lesions.

" The experiment confirms the general exper--ience that Indian cattle are less commonly affected by tuberculosis than English cattle are, and supports the view that the comparative infrequency of the disease in India is due to a natural resistance rather than to any method of housing or keeping cattle in India as compared with England.

" Nevertheless certain Indian calves seem to die as quickly from generalised tuberculosis, after the subcutaneous inoculation of even 10 mgms. of culture, as English calves do, so that there is a considerably greater individual variation in susceptibility to infection by the tubercle bacillus among Indian as compared with English calves. Whether this variation be associated with differ--ences in the breeds of the calves used by us has not yet been determined. It, however, follows that the comparative rarity of tuberculosis in Indian cattle must in part at

(least

least be attributed to diminished opportunities for acquir--ing infection.

" The possible existence of tuberculosis among certain imported breeds of cattle and their liability to contract tubercular infection is therefore a source of danger to indigenous herds. One out of three definite cases of tubercular disease in cattle in India which came under our observation was found in an English bull which had been kept at the Allahabad Military Dairy Farm. Attention should be paid to this point when attempting to develop a more useful milk-yielding stock than is at present available among the indigenous breeds.

" It remains only to draw attention to another important point. On account of the constancy with which a dose of 50 mgms. of a culture of tubercle bacillus of bovine type causes acute generalised tuberculosis when injected subcutaneously into calves, this method has been recommend--ed by all great workers in Europe and America, as a means of distinguishing between tubercle bacilli of typus bovinus and typus humanus. Our experiments prove that, when using Indian breeds of cattle at least, this test cannot be relied on, for in 50 per cent. of the calves the effects produced by such an inoculation do not materially differ from the effects produced by the injection of a similar dose of tubercle bacilli of typus humanus in English cattle.

" Incidentally our experiment sheds some light on the practical absence of tuberculous lesions caused by the bovine type of bacillus in children and adults in India. This is a subject which will be discussed in a subsequent paper. "

Sheather (1921) carried out inoculation experiments on buffalo and cow calves using a local strain of tubercle bacilli isolated from a tuberculous bovine.

(Five

Five buffalo calves received 10 mg. of culture subcutaneously and five received 50 mg. Twelve cow calves were similarly inoculated half receiving 10 mg. of culture and half 50 mg. None of these animals died of the inoculation and they were killed off between 152 and 159 days later.

All animals put on weight and the post-mortem examinations were classified as follows :-

(a) Fourteen Animals :- Slight tuberculosis. A lesion at the site of inoculation. Lesions in the thoracic glands and possibly abdominal glands. A few lesions in the lungs or spleen.

(b) Five Animals :- Extensive but not severe. As above but with the addition of tuberculous pleurisy or peritonitis or both.

(c) Three Animals :- Generalised but not progressive. Cases in which there was evidence of invasion of the organs by way of the blood stream with the production of numerous lesions in the lungs.

The results are compared with those of the Royal Commission on Tuberculosis (2nd. Interim Report , Part II, Appendix Vol. I, p. 34), which showed that a subcutaneous dose of 50 mg. of culture almost invariably produced fatal generalised tuberculosis within seven weeks and in the case of a 10 mg. dose 60% died within eight weeks.

The author concludes that from his experiments both on rabbits and on cattle that the virulence of the tubercle bacillus isolated from Indian cattle is lower than that isolated from cattle in Europe. He states : " Glen Liston's experiments indicated that Indian cattle are less susceptible to infection with the tubercle bacillus than English animals when tested with a virus of European origin.

" The experiments here recorded indicate that this is not the sole or possibly even the most important factor in determining the comparatively frequent occurrence

(of

of tuberculosis in Indian cattle. They appear to indicate beyond all possibility of doubt that the strains of tubercle bacilli affecting cattle in India possess a distinctly lower degree of virulence than tubercle bacilli isolated from cattle in Europe.

"A point which would appear to support the view that the lower virulence of the organism is the more important factor is that in practically every instance the natural lesions which have come under observation have been restricted to a few glands and have been to a very large extent calcified. "

Soparkar (1926) carried out a large scale experiment to test the susceptibility of various Indian breeds of cattle to tuberculosis. A type strain obtained from the National Collection was used in a dose of 50 mg. inoculated subcutaneously. 141 calves were used in the experiment, and the results showed that whilst a consider--able number (48) proved very resistant and remained well and lived beyond 90 days, the susceptibility varied considerably. Ninety-three died of acute generalised tuber--culosis in periods varying from 17 to 101 days. Apparently out of these 93, only 10 showed the very severe type seen in English calves.

The author summarises the position in the following paragraph :-

" While the experiments of the Royal Commission on Tuberculosis show that a dose of 50 milligrammes of culture of bovine origin given subcutaneously is almost invariably sufficient to overcome the resistance of English (Jersey) cattle, and, with rare exceptions, produces generalised tuberculosis of a severe type which proves rapidly fatal, the results of the present experiments would indicate that a certain proportion of Indian calves equally

(small

small in size remain well after similar infection, and, when autopsied, show slight or minimal lesions, indicating that they are possessed of very high powers of resistance to tuberculosis as compared to English calves."

Soparkar (1927) in a paper dealing with the virulence of tubercle bacilli isolated from cattle in India, reviews Sheather's (1921) results and quite rightly draws attention to the fact that Sheather used cultures which were six months old, which of course detracts considerably from the significance of his results.

Soparkar carried out inoculation experiments on rabbits and calves using both European and Indian strains of tubercle bacilli. Of the European strains actively growing young cultures were used, also cultures which were six months old. Of the Indian strains only young cultures were used.

It is difficult to draw definite conclusions from the results, but it is quite evident that the European strains six months old were not by any means as virulent as the young cultures, either in rabbits or calves. It is unfortunate that six-months old Indian strains were not used in order to make a direct comparison with Sheather's work.

Two series of calves were inoculated, one with 21-day old European cultures (Table V), and the other with Indian cultures of the same age (Table VII).

On examination of Table V, i.e., the inocula--tions with European cultures, 13 of the 24 calves died in an average period of 40 days, whilst Table VII, i.e., the inoculations with Indian strains, shows that 15 calves died out of 19, but the average period of survival was 71 days.

It is difficult to say on these results whether one strain is more or less virulent than the other. However,

(a

a number of calves inoculated with the Indian strain did, in fact, die of acute generalised tuberculosis in the same way as those inoculated with a known virulent strain of European origin. This is important and indicates that the Indian strain was not of markedly low virulence, and that individual differences in resistance existed in the subjects inoculated.

It will be recalled that none of Sheather's (1921) calves died, and when killed they only showed local lesions. All the Indian strains proved highly virulent for rabbits in the same manner as the type European strain.

Soparkar's findings are as follows : " The rarity of gross tuberculous lesions hitherto observed among indigenous cattle and the usual tendency of the lesions to remain localised in affected animals, cannot therefore be ascribed to any note-worthy difference in the virulence of the infecting organisms. "

It must be remembered that the indigenous cattle of India are all Zebu in type.

EXPERIMENTS IN UGANDA.

Experiments were carried out in Uganda in order to determine whether the local Zebu, in which tuberculosis is rare, are specifically more resistant to the disease than the Ankole cattle, among which tuberculosis is frequent.

The number of cattle used in these experiments might well have been many more, but the question of expense had to be taken into account. It was impossible to obtain pure Ankole and Zebu calves, so that much larger animals than those used either by the Royal Commission or in the Indian experiments had to be utilised.

In all cases the experimental animals were submitted to the tuberculin test (double intradermal) and, of course, only animals thus proved to be free from

(spontaneous

spontaneous tuberculosis were inoculated.

The strains used for inoculation experiments in Uganda are as follows :-

1. Bovine virus No. 3126 obtained from the National Collection of Type cultures, Lister Institute, London.

2. Local Bovine virus known as " Wandegeya A ", isolated from a caseous mediastinal gland of an Ankole bullock killed in Kampala abattoir. This is a normal dysgonic bovine strain of standard virulence for rabbits, the details of which are given under the list of strains isolated from Uganda cattle.

All inoculations were made subcutaneously in front of the shoulder, and no culture used was more than 30 days old.

EXPERIMENT 1.

(a) Young Ankole bull No. 1281, weighing 442 lbs., was inoculated on 28-6-34 subcutaneously in front of the shoulder with 50 mg. of Type bovine culture.

(b) Young Zebu bull No. 1399, weighing 308 lbs., received the same dose of the same strain of culture on 28-6-34.

The Zebu animal died on 25-7-35, and the Ankole beast was killed the same day and the autopsies carried out at the same time.

Post-mortem Examinations :-

A. Ankole 1281. Very emaciated. Loss in weight 14 lbs. Right prescapular gland enlarged and consisted of a mass of firm tuberculius tissue. Left prescapular gland enlarged and indurated. Mediastinal and bronchial glands enlarged and caseous. Lungs were distended and full of miliary tubercles. Hepatic gland enlarged and indurated and liver showed numerous miliary tubercles below the capsule. Spleen showed numerous miliary tubercles.

This animal showed no resistance to the inoculation of 50 mg. of tubercle bacilli, and would undoubt-edly have died in a few days.

B. Zebu 1399. Carcase very emaciated. Loss in weight 27 lbs. Right prescapular gland consisted of a large mass of tubercu-lous tissue. Left prescapular gland slightly enlarged. Mediastinal and bronchial glands enlarged, indurated and caseous. Hepatic glands enlarged and indurated. Liver showed no macroscopic lesions. Lungs: acute tuberculous pneumonia, distended and full of miliary tubercles. Pleurae: a small area of circumscribed pleurisy on left parietal pleura.

Although the Ankole animal showed slightly

(more

more tissue resistance to the same dose of virus there was no marked difference. Both animals contracted acute miliary tuberculosis.

EXPERIMENT 2.

Ankole bull No. 1365, weight 401 lbs.) Both animals received
) 50 mg. of Type culture
Zebu bull No. 1398, weight 304 lbs.) subcutaneously on
25-5-34.

The Ankole animal was killed in extremis on 28-6-34, and the Zebu bull was killed on the same day and autopsies carried out at the same time.

Post-mortem examinations :-

A. Ankole 1365. Carcase very emaciated, loss in weight 63 lbs. Right prescapular gland enlarged and consisted of a mass of fibrous tuberculous tissue. Left prescapular enlarged. Mediastinal and bronchial glands caseo-fibrous and enlarged. Retropharyngeal glands contained a few tubercles. Lungs: acute miliary tuberculosis.

B. Zebu 1398. Carcase poor condition but not emaciated. Loss in weight 20 lbs. Right prescapular gland consisted of a large mass of tuberculous tissue. Left prescapular gland enlarged. Mediastinal and bronchial glands enlarged, indurated and contained a number of caseous nodules. Hepatic gland enlarged. Lungs were full of fairly large tubercles, about the diameter of a three-penny piece.

The Zebu animal showed more resistance to the dose of virus than the Ankole bull. Its condition was better and the lesions were not so fulminating in character. They were both, however, severely infected.

EXPERIMENT 3.

Ankole bull No. 1331, weight 484 lbs., received 50 mg. of type culture subcutaneously on 3-7-34. It died on 31-7-34.

Post-mortem examination :-

Ankole 1331. Carcase very emaciated, loss in weight 53 lbs. Right prescapular gland enlarged and consisted of a mass of firm tuberculous tissue. Mediastinal and bronchial glands enlarged and indurated, but not caseous. Lungs distended. Acute tuberculous pneumonia.

EXPERIMENT 4.

Ankole bull No. 1283, weight 484 lbs., and Zebu bull No.1401, weight 401 lbs., both received 30 mg. of local bovine culture on 4-1-35. The Ankole animal died on 15-2-35, and the Zebu was killed on the same day and autopsies carried out.

Post-mortem Examinations :-

(a) Ankole 1283. Greatly emaciated. Loss in weight 39 lbs. Left prescapular gland consisted of a large mass about the size of a melon composed of firm tuberculous tissue. Right prescapular gland enlarged and indurated. Retropharyngeal glands enlarged and indurated. Supra-sternal gland enlarged and caseous. Mediastinal and bronchial glands enlarged and caseous. Lungs: severe miliary tuberculosis.

(b) Zebu 1401. Condition excellent. Loss in weight 4 lbs. Peri-renal and pelvic fat in abundance. Left prescapular gland enlarged and fibro-caseous. Mediastinal glands enlarged but no caseation. Lungs: full of scattered tubercles about 3-4 mm., in diameter.

The marked difference in the condition and pathological changes in these two animals was most striking. The Zebu had shown a very definite resistance to infection as compared with the Ankole animal.

EXPERIMENT 5.

Ankole animal No. 1315, weight 496 lbs., and Zebu No. 1369, weight 400 lbs., received 50 mg. of local bovine culture on 12-1-35. The Ankole animal died on 15-2-35, and the Zebu was killed on the same day for comparative examination.

Post-mortem Examinations :-

(a) Ankole 1315. Greatly emaciated. Loss in weight 79 lbs. The adjacent (prescapular) gland was enlarged enormously and consisted of a mass of hard yellow fibro-caseous material. Left prescapular gland enlarged but no caseation. Mediastinal and bronchial glands greatly enlarged with caseation beginning. Lungs: acute miliary tuberculosis. Liver: miliary tubercles throughout the gland.

(b) Zebu 1369. Excellent condition. Loss in weight 11 lbs. The adjacent (right prescapular) gland was greatly enlarged and about the size of a melon, consisting of caseo-fibrous material. Left prescapular: slightly enlarged. Mediastinal and bronchial glands enlarged and caseo-fibrous. Lungs: full of scattered tubercles about 3 mm., in diameter and tending to become encapsulated. Liver: numerous small millet seed tubercles below the capsule. Hepatic glands enlarged and indurated. Kidneys: scattered small tubercles in both organs.

Although the extent of the infection was greater in the Zebu than in the Ankole its general condition was excellent and its resistance marked.

EXPERIMENT 6.

Zebu No. 1397, weight 352 lbs., and Ankole No. 1352, weight 464 lbs., were inoculated with 10 mg., of local bovine culture on 14-9-34. They were both killed for examination on 11-5-35.

Post-mortem Examinations :-

(a) Ankole 1352. Condition fair. Increase in weight 55 lbs. Adjacent (right prescapular) gland enlarged and indurated but contained no tubercles. Left prescapular gland slightly enlarged. Lungs: marked bilateral pleurisy with fibrinous adhesions and perlsucht tubercles commencing on the parietal pleurae. The substance of the lungs was full of firm caseous tubercles about 2 mm., in diameter scattered through--out the parenchyma. Mediastinal and bronchial glands enlarged and showing a few small tubercles tending to calcification. Liver: hepatic gland enlarged and indurated and containing a few hard tubercles. There were a few hard tubercles below the capsule of the gland on the diaphragmatic surface which showed marked fibrinous peritonitis. Peritoneum - fibrinous peritonitis commencing.

(b) Zebu 1397. Fair condition. Increase in weight 46 lbs. Adjacent (right prescapular) gland enlarged and indurated and deeply pigmented with melanin. Left prescapular gland also enlarged and pigmented. Thoracic cavity showed a localised patch of perietal pleurisy with adhesions. Lungs: normal. Mediastinal glands slightly enlarged. Kidneys both showed severe scarring of the surface of the cortex, and on section numerous small tubercles in the medullary and intermediate zones were present. Peritoneal cavity normal.

Both animals were in fair condition but the extensive character of the infection in the Ankole as compared with the Zebu was most marked.

EXPERIMENT 7.

Zebu No. 1400, weight 340 lbs., and Ankole No. 1333, weight 451 lbs., were inoculated subcutaneously with 50 mg., of a human culture isolated from a phthisical Muhima on 14-9-34. It will be recalled that the Bahima are a pastoral tribe who own the Ankole cattle. Both animals were killed on 1-5-35 for examination.

Post-mortem Examinations :-

(a) Ankole 1333. Excellent condition. Increase in weight 195 lbs. The adjacent (left prescapular) gland was swollen and contained an abscess consisting of about 100 c.c., of thick yellow creamy pus. The abscess was firmly encapsulated and acid-fast organisms were numerous on microscopic examination. The rest of the carcase was normal.

(b) Zebu 1400. Excellent condition. Increase in weight 181 lbs. The adjacent gland was enlarged to about three times its normal size and was harder than usual. Acid-fast organ--isms were not seen in films from this gland. The rest of the carcase was normal.

As was to be expected, the local cattle are not susceptible to the local strain of tubercle bacilli of the human type. Pus from the abscess in the Ankole animal was cultured and had not lost any of the normal cultural characteristics typical of the human type of organism. A guinea-pig inoculated was killed 156 days later and showed advanced tuberculosis of the glands, spleen and liver, with a few scattered tubercles in the lungs.

A summary of the results obtained in these experiments is given in the table below.

TABLE SHOWING RESULTS OF INOCULATING ZEBU AND ANKOLE CATTLE WITH TUBERCLE BACILLI: SUMMARY OF EXPERIMENTS.

No. of Animal.	Type of Animal.	Dose.	Origin of strain.	Killed or died.	Period of survival in days.	Gain or loss in Weight in lbs.	T.B. lesions on Autopsy :-
1281.	Ankole.	50 mg.	Type, Bovine.	Killed.	27.	- 14.	∓ ∓ ∓
1399.	Zebu.	50 mg.	Type, "	Died.	27.	- 27.	∓ ∓ ∓
1365.	Ankole.	50 mg.	Type, "	Killed in extremis.	34.	- 63.	∓ ∓ ∓
1398.	Zebu.	50 mg.	Type, "	Killed.	34.	- 20.	∓ ∓ ∓
1331.	Ankole.	50 mg.	Type, "	Died.	28.	- 53.	∓ ∓ ∓
1283.	Ankole.	30 mg.	Local, "	Died.	42.	- 39.	∓ ∓ ∓
1401.	Zebu.	30 mg.	Local, "	Killed.	42.	- 4.	∓ ∓
1315.	Ankole.	50 mg.	Local, "	Died.	34.	- 79.	∓ ∓ ∓
1369.	Zebu.	50 mg.	Local, "	Killed.	34.	- 11.	∓ ∓ -
1397.	Zebu.	10 mg.	Local, "	Killed.	239.	∓ 46.	∓
1352.	Ankole.	10 mg.	Local, "	Killed.	239.	∓ 55.	∓ ∓ -
1400.	Zebu.	50 mg.	Local Human.	Killed.	229.	∓ 181.	- - -
1333.	Ankole.	50 mg.	Local Human.	Killed.	229.	∓ 195.	- - -

Note:- The above table is compiled in order to facilitate reference. Under the column "T.B. lesions on Autopsy" the signs are intended to indicate my conclusions as regards the extent and severity of the lesions combined with the general condition of the animal post-mortem.

DISCUSSION OF RESULTS.

These experiments are recorded as work carried out and it is realised that with the small number of animals inoculated it is impossible to draw any definite conclusions from the results obtained. However, the indications are that both the Ankole and Zebu animals are equally susceptible to a type European bovine strain of tubercle bacillus, whilst in the case of a local bovine virus the Ankole cattle are much more susceptible than the Uganda Zebus. Reference to the work carried out on local bovine strains will show that culturally, and in their pathogenicity towards rabbits, they resemble the classical European strains.

As mentioned bofore, it would have been preferable to have used small calves, but in Uganda they are almost impossible to obtain unless the cows are bought with them which makes a large experiment of this kind an expensive and cumbersome undertaking.

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UGANDA PROTECTORATE
AVERAGE RAINFALL

Statute Miles

0 20 40 60 80 MILES

ANNUAL RAINFALL OF

UNDER	35	INCHES	
35 INCHES	— 45	,,	
45 ,,	— 55	,,	
55 ,,	— 65	,,	
65 ,,	— 75	,,	
OVER	75	,,	

FIGURES SHOWING THE PERCENTAGE OF TUBERCULOUS INFECTIONS FROM SLAUGHTER HOUSE RETURNS 1931 - 1935.

SUDAN

KENYA

CONGO BELGE

TANGANYIKA

LAKE VICTORIA

WEST NILE

CHUA

GULU

KARAMOJA

1.3% out of 8,302

0.93% out of

10,459

16.3% out of 5,954

Nimule

Kitgum

Arua

Gulu

Moroto

Lira

Soroti

Hoima

Masindi

Butiaba

Serere

Mbale

Bubulu

Budini

Tororo

Fort Portal

Mubende

Jinja

KAMPALA

ENTEBBE

Masaka

Mbarara

Kisumu

Kabale

Albert Nile

Victoria Nile

L. KWANIA

L. KYOGA

ZOKA FOREST

BUDONGO FOREST

BUGOMA FOREST

KIBALE FOREST

RUWENZORI

MABIRA FOREST

KALINZU FOREST

KAYONZA FOREST

ELGON

LAKE ALBERT

LEDWARD

BUNYORO

TORO

ANKOLE

BUSOGA

BUGWERE

BUGISHU

BUDAMA

COLONY

31° 33° 35° 4° 2° 0°

Uganda Survey Dept. 1935.

MAP OF GANDA PROTECTORATE

Scale 1" = 24 MILES.

Figures show cattle population in each District total cattle population December 1932 = 2,151,668 head.

Type of native cattle owner and human population in each district shown in red.

- Ankole Type of Cattle.
- Zebu Type of Cattle.
- Intermediate Type of Cattle.

SUDAN

Tribes of West Coast Negroid type

WEST NILE

188,509 250,427

NILOTIC

Albert Nile

43,040 101,060

GULU

NILOTIC

NORTHERN PROVINCE

NILOTIC 82,574

CHUA

38,422

HAMITIC 65,578

150,000

KARAMOJA

R. Victoria Nile

NILOTIC

LANGO

327,577 224,150

274,255

HAMITIC

361,674

EASTERN PROVINCE

CONGO

LAKE ALBERT

BUNYORO

113,950

BANTU

6989

WITH HAMITIC STRAIN

61,364 352,916

BANTU

MUBENDE

BUGANDA

BANTU

33,395 156,132

MENGO

LAKE KIOGA

TESO

179,485

BUGWERE

110,033

BUGISHU

185,057

165,758

385,900

117,427

BANTU

BUSOGA

152,730

BANTU

BUDAMA

88,198

KENYA

NILOTIC

R. NILE

BANTU

62,091 195,419

TORO

WESTERN PROVINCE

186,391 ENTEBBE 23,560

BANTU

L GEORGE

100,000 179,138

BANTU and HAMITIC

MASAKA

L EDWARD

ANKOLE

183,341 282,077

HAMITIC

KAVIRONDO GULF

MAINLY BANTU

KIGEZI

92,290 236,896

RUANDA

LAKE VICTORIA

Kagera River

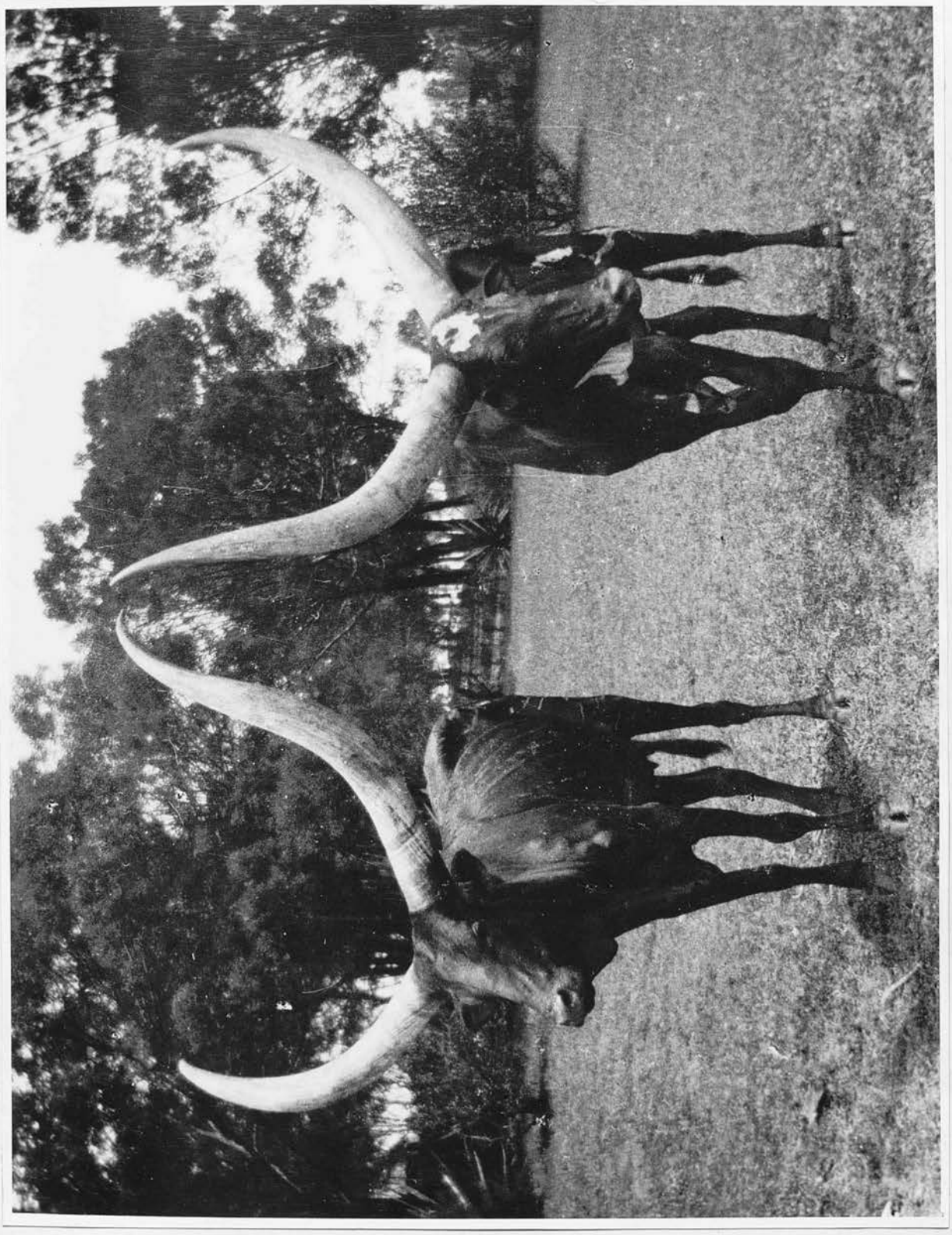
TANGANYIKA

THE TIMES OF INDIA PRESS, BOMBAY.

Fig. 1.

AN ANKOLE BULLOCK.

Fig. II

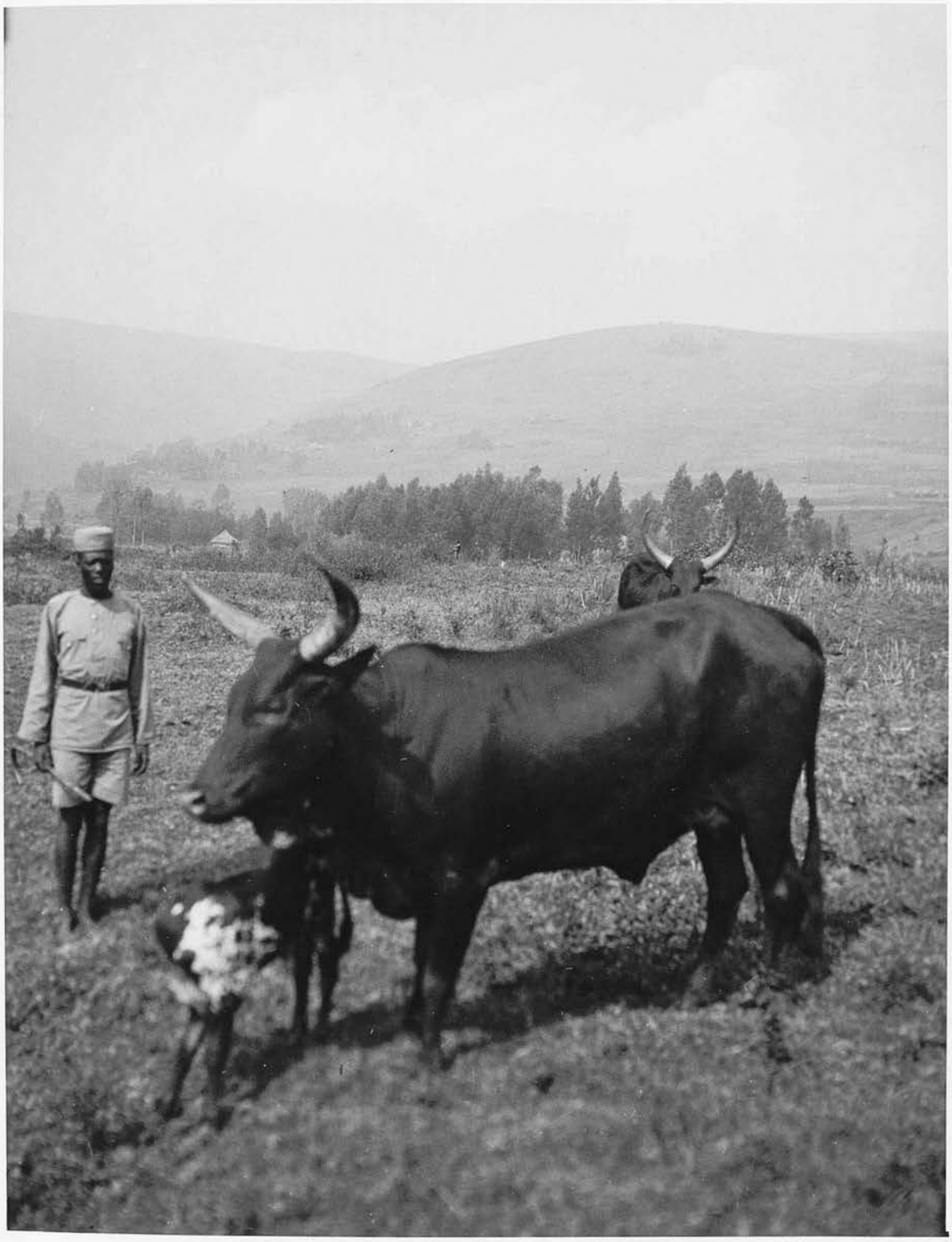


SPECIMENS OF ANKOLE COWS.

Fig. III

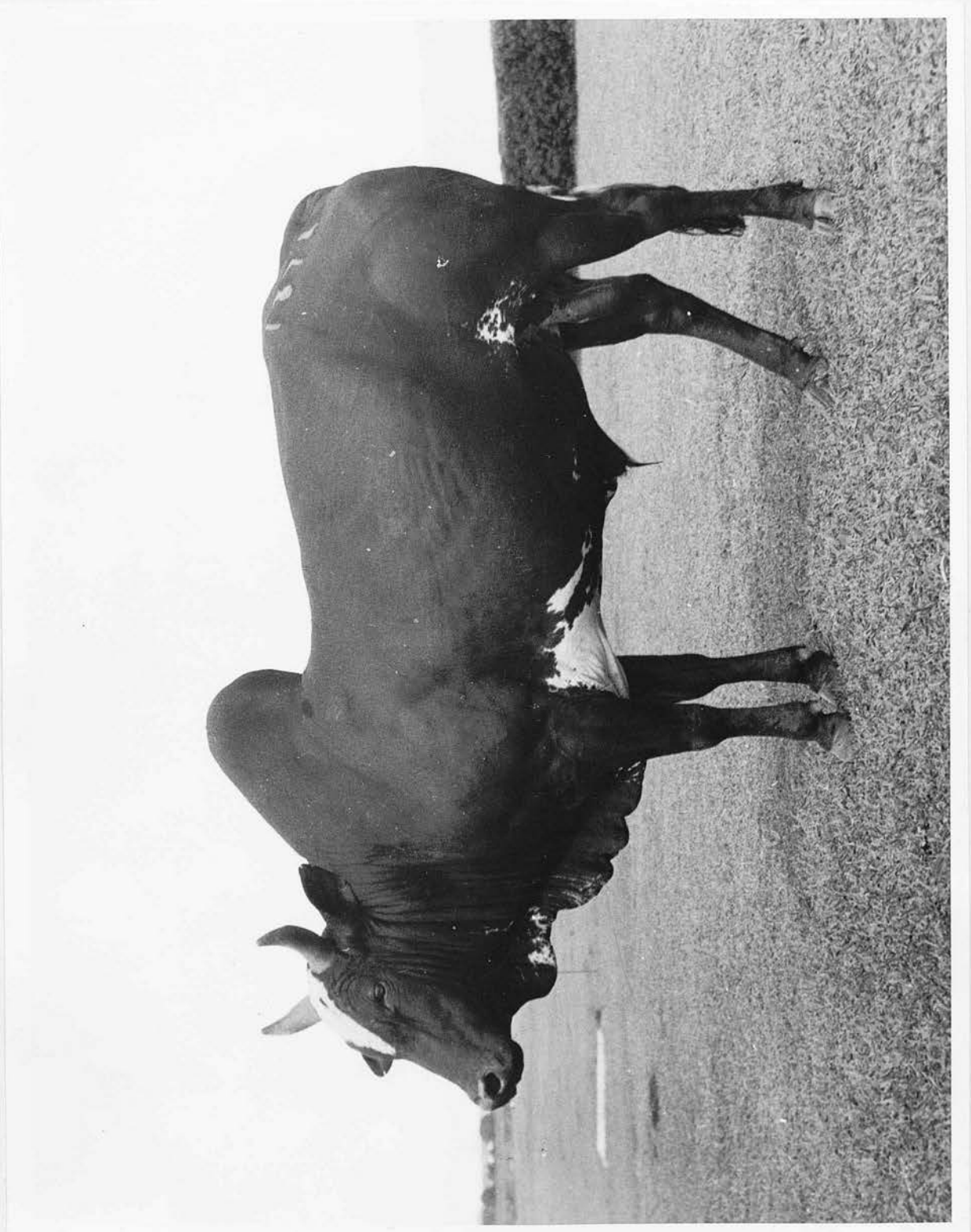
A VIEW SHOWING THE OPEN GRASS LAND OF ANKOLE .

Fig. IV



KIGEZI CATTLE - INTERMEDIATE TYPE .

Fig. V

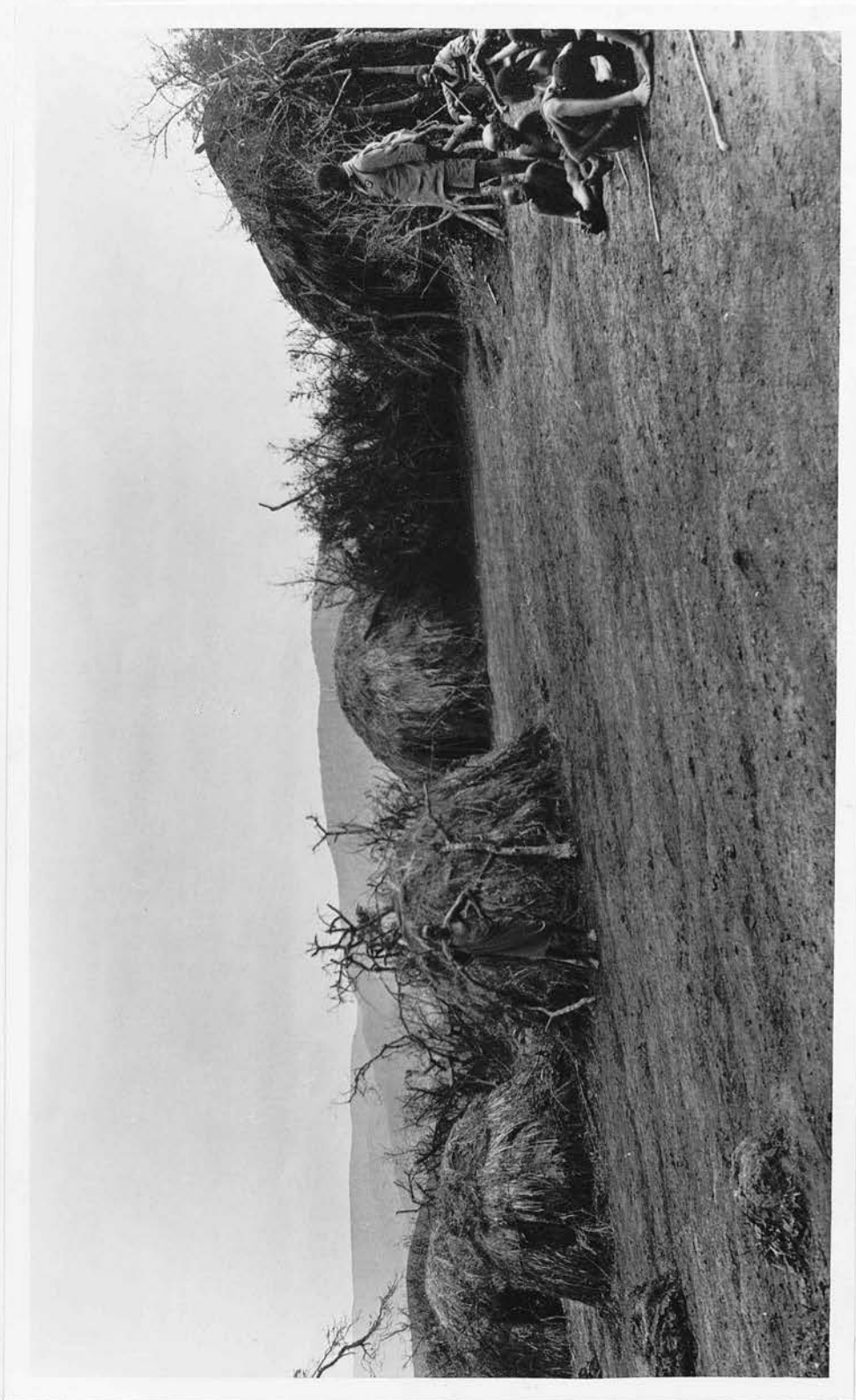


A TYPICAL ZEBU OX IN UGANDA.

Fig. VI

ANOTHER VIEW OF THE BAHIMA (ANKOLE) CATTLE KRAAL.

Fig. VII

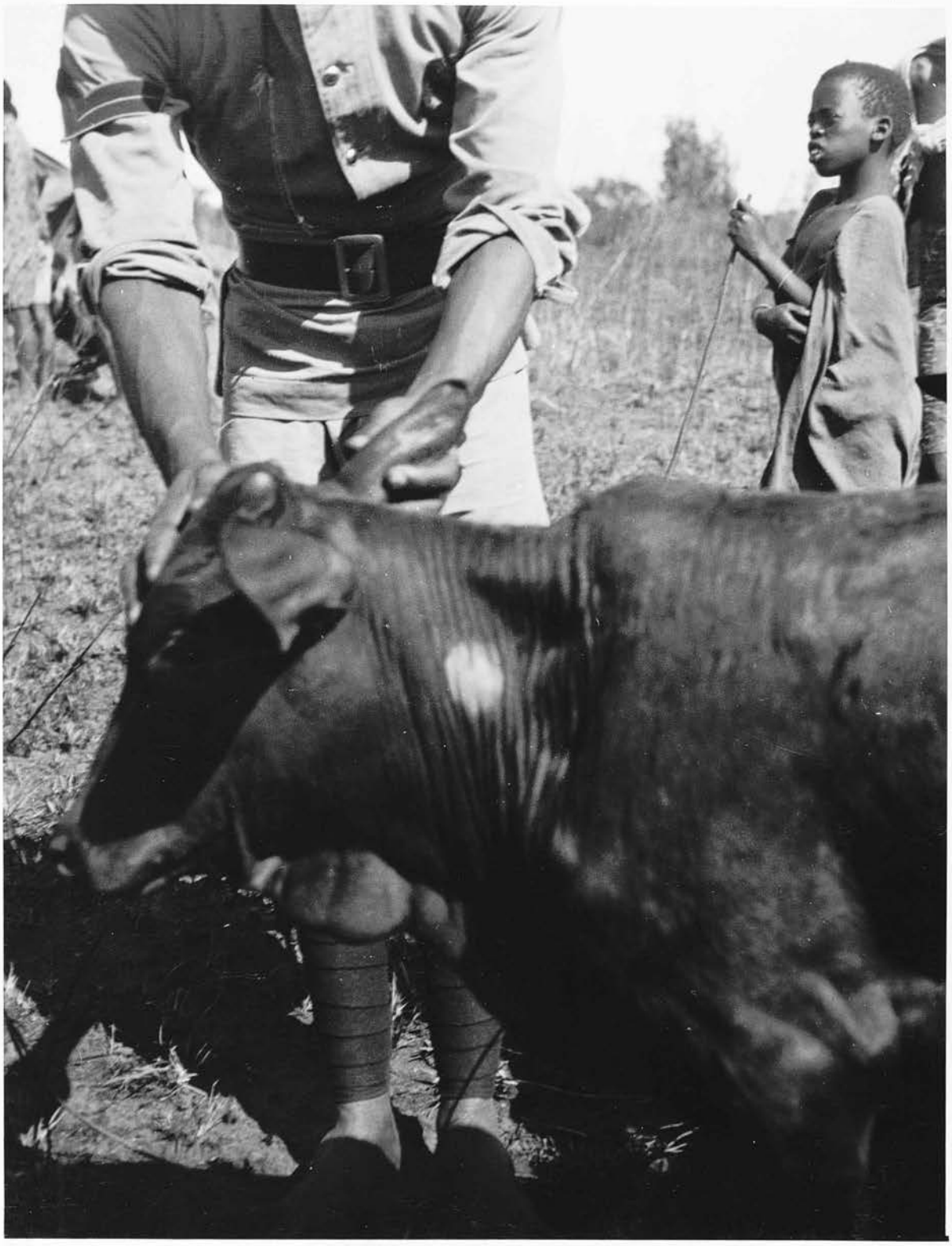


A TYPICAL BAHIMA (ANKOLE) CATTLE KRAAL SHOWING THE NATIVE HUTS AND HEAPS OF CATTLE DUNG USED FOR SMUDGE FIRES.

Fig. VIII

TUBERCULIN TESTING IN ANKOLE - MEASURING THE SKIN FOLD.

Fig. IX



A POSITIVE TUBERCULIN REACTION IN A YEARLING ANKOLE HEIFER .

Fig. X

THE NATIVE TREATMENT FOR TUBERCULOSIS IN ANKOLE . NOTE THE BRAND MARKS ON THE THORAX .

PART IV

TUBERCULOSIS IN SHEEP

(A). REVIEW OF THE LITERATURE.

Tuberculosis in sheep is recognised as being a rare condition, and of the millions of sheep annually slaughtered for food throughout the world it is very excep--tional to find lesions of this disease.

The literature on the subject is not extensive. As a matter purely of historical interest, the first mention of tuberculosis in sheep which has come to my notice is a paper by Barton (1867), who reports the post-mortem findings on a lamb which had died of " staggers ". He states, inter alia, : "The base of the cerebellum was completely destroyed as were also some portions of the medulla oblongata, the medullary substance being replaced by tubercular cells." This was fifteen years before Koch's discovery of the mammalian tubercle bacilli.

Steel (1893) mentions that there is no evidence that true tuberculosis is a disease of ovines. He quotes Dun (1869) who speaks of " Scrofulous lung, throat, joints, and osseous disorders in sheep due to hereditary influence as undermining the animal's constitution."

He also states that the only indubitable instance of the disease which had occurred up to that time was in a lamb which had been fed on the milk of a tuberculous cow and was reported by Bollinger (1873).

The first authentic case recorded in Great Britain was investigated by M'Fadyean (1900). The material available was the side of a sheep which had been seized in a slaughter house in December, 1898.

On the parietal pleura there were clusters of nodules very like those of perlsucht in cattle. Two rabbits were inoculated with caseo-purulent material, and died 130 and 154 days afterwards respectively. Further rabbits were inoculated and a culture obtained from the last rabbit of the series, but this was not further investigated.

A further case was reported by M'Fadyean (1902). The animal was a cross-bred ewe and showed lesions of advan--ced generalised tuberculosis, with particular localisation in the lungs one of which was to a large extent destroyed and replaced by caseous and partially calcified material. Two guinea-pigs were inoculated with infected material from the lung and liver respectively. One died of generalised tuberculosis in 72, and the other in 77, days. A culture obtained from the lung lesions showed, after three weeks incubation, a large number of short uniformly stained tuber--cle bacilli, although no acid-fast organisms were detectable on direct examination of the infected material.

The next case was recorded by Fullerton (1902). This sheep, on post-mortem examination, showed numerous tubercles in the lungs with extensive consolidation. There were numerous nodules on the pleura, and tubercles were present in the liver, spleen, and both kidneys. A right inguinal gland, the sternal, cervical, mesenteric, lumbar anterior mediastinal, and dorsal lymphatic glands contained caseating patches. Guinea-pigs were inoculated and on post-mortem showed caseation of the regional glands.

No information was given in M'Fadyean's cases or Fullerton's case regarding the cultural characteristics of the organism.

Owing to the pathogenicity to rabbits and the severity of the lesions produced, M'Fadyean's first case was probably bovine. His second case was mammalian, probably

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bovine; whilst in Fullerton's case no opinion can be express--ed except that the disease did not extend beyond the glands adjacent to the site of inoculation, and was therefore only slightly pathogenic to these animals. This is not a characteristic feature of a normal mammalian strain.

Ostertag (1907) points out that whilst tuberculosis is rare in sheep and goats they are susceptible to the disease. This is shown by the occurrence of sponta--neous infection, and by inoculation experiments.

He quotes figures for the year 1890 to show that in Saxony the percentage of tuberculous sheep as seen in slaughter houses was 0.02%, whilst for the same year in Berlin the percentage was 0.0048%. In Saxony the percentage of tuberculosis in sheep sank from 0.15% in 1894, to 0.07% in 1896, and to 0.06% in 1899. This improvement was consi--dered to be due to the fact that in previous years pseudo--tuberculosis had been confused with the true disease. It is significant to mention, in this connection, that tubercu--losis in sheep is scarcely referred to in Young's edition of Ostertag's book (1934).

Wallis Hoare (1913) refers to the rarity of tuberculosis in sheep, and quotes M'Fadyean's and Fullerton's cases (vide supra). He refers to a case in sheep recorded by Moussu (no reference given), where the animal had been kept in contact with tuberculous cows for two years.

Mouquet (1918) reported two cases in Barbary wild sheep (O. tragelaphus). They were in captivity, and he suggests that infection was of the human type, and might have been carried by a tuberculous keeper or by rats. No evidence is given in support of this opinion, nor was any bacteriological examination carried out.

Griffith (1925) in an excellent paper reviews the British cases reported to that date, and records two

(cases

cases in sheep in which the avian type of bacillus was responsible for infection. Detailed accounts are given of cultural characteristics and inoculation experiments with weighed amounts of culture. Guinea-pigs, rabbits, fowls, sparrows, sheep and goats were used in the determination of the type of tubercle bacillus. No case of tuberculosis in sheep had, up to that time, been investigated by a study of a culture with a view to typing the organism.

Edelman, Mohler and Eichorn (1925) state that sheep are almost immune to tuberculosis, as only 7 carcases were found infected in 1922 out of 12,000,000 sheep inspected by the Federal Meat Inspection Services of the United States of America.

The statistics of meat inspection in the German Empire are quoted for 1918, and show that 0.02% of sheep were tuberculous.

Hutyra and Marek (1926) describe the clinical disease in sheep.

Leighton (1927) gives no reference or figures but states that tuberculosis in the case of sheep and goats occurs in 0.002% of these animals.

Jowett (1928) records two cases of ovine tubefculosis which were encountered at the Gorgie abattoirs in Edinburgh.

In the first case the lungs were crepitant but contained many nodular lesions and a few solid areas. The nodular lesions showed a fibrous periphery with a fibro--caseous interior, and the majority were about 1 cm., in diameter. An extensive lesion measuring about 15 cms., in length, and 5 cms., broad, extended along the base and the upper border of the right lung. The left lung showed two large fibro caseo-calcareous areas each about the size of a (hen's

hen's egg, together with numerous smaller nodular lesions scattered throughout the substance of both lungs. The bronchial and mediastinal glands were much enlarged, and about the size of a hen's egg. They were firm in consistence and contained fibro-caseous nodular lesions, some of which were extensively calcareous. The liver contained many nodular fibro-caseous lesions, and the portal lymphatic glands were enlarged and firm, and contained fibro-caseous and calcareous material. Acid-fast organisms were not found on direct examination of the tuberculous material from the lungs and affected glands. Guinea-pigs were inoculated and on post-mortem showed lesions of generalised tuberculosis. Cultures were obtained which proved to be dysgonic. A rabbit was inoculated with 0.1 mg., of culture intravenously and died 21 days afterwards with lesions of acute miliary tuber--culosis of the lungs. The culture was also pathogenic to a guinea-pig in a dose of 0.1 mg., intramuscularly. The organism was evidently of the bovine type.

The second sheep showed lesions only in the liver, the other organs being, it was stated, quite normal. Acid-fast organisms were not found on microscopical examina--tion of the fibro-caseous material from the liver tubercles or from the hepatic gland which was also infected. Cultures were obtained through a guinea-pig inoculated from the sheep material. A dysgonic growth on glycerine media was obtained, and the bovine type of tubercle bacillus confirmed by rabbit inoculation.

Ferwerda (1928) in discussing tuberculosis in sheep states that the lymph glands are always found to be calcified, and advances the hypothesis that the parathyroid glands may be responsible for this, the pastoral existence of the sheep, and the vitamins in the herbage, possibly

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providing the necessary stimulus for the endocrine activity. There is a notable lack of experimental evidence in support of this hypothesis.

Oppermann (1929) refers to the rarity of tuberculosis in sheep and gives a short account of the etiology, pathogenesis, pathological anatomy, symptoms and differential diagnosis. He quotes the following figures from Ostertag (1923), showing the incidence of tuberculosis in sheep met with in slaughter houses in Germany :-

	Year	Percentage Incidence
Prussia :-	1898.	0.11
	1899.	0.12
	1910.	0.0019
	1911.	0.0012
	1912.	0.0017
	1923.	0.0015
Saxony :-	1894.	0.07
	1896.	0.06
German Empire :-	1912.	0.14
Also Moscow slaughter houses (no date) :-		0.09

He considers that the tubercle bacillus is usually taken in with food, but some maintain also by inhalation. Infection occurs mainly in young lambs fed with cow's milk. Reference is given to Koch and Petit's opinion that if older sheep co-inhabit with tuberculous cattle they can contract the disease.

Other authorities quoted are Reinhart (1921), who considers that generalised tuberculosis is very rare in sheep, whilst Rasmussen (1894) is said to have seen tuber--culous nodules in the vertebrae of sheep. Bottcher (1908) is quoted as having recorded tuberculous lesions in the cerebrum and cerebellum of sheep.

Davidov (1930) records a case of spontaneous tuberculosis in a sheep in Russia. The clinical symptoms showed a normal temperature with increased pulse and respi--rations. The conjunctiva and buccal mucous membranes were (slightly

slightly cyanosed. The submaxillary glands were indurated and enlarged. There was dullness on percussion of the chest, whilst auscultation revealed nothing of importance. On post-mortem there were patches of consolidation in the lungs and tuberculous foci were present in the parenchyma. Two miliary tubercles are said to have been found in the wall of the larynx. The mediastinal glands were greatly enlarged and weighed up to 562 grammes. On dissection there was a thick lamellated capsule of connective tissue, inside which was a small strip with flesh-like contents of saffron colour. There was no calcification. A pure culture of tubercle bacilli is said to have been obtained. No cultural investi--gations or animal experiments with a view to typing the organism are recorded.

Salvi (1932) in a long paper reviews the literature on tuberculosis in sheep. The detailed references, however, are not given in the original article, but only in the reprints of the paper which I was unable to procure. A certain amount of emphasis is given to the belief that the sheep is resistant to tuberculosis on account of the high degree of calcification which accompanies tubercular lesions in these animals, and Petit, Mayer, Nieberle and Eber are quoted in support of this observation.

As will be pointed out later, calcification was certainly not a constant feature in all cases of tuber--culosis in sheep examined in Uganda, though it was present in some of them.

Salvi (1932) also quoted Myschkin's figures from the Moscow abattoir. He observed two cases and records that in the year 1897, of 29,478 sheep slaughtered, only 27 or 0.09% were tubercular. Salvi in the same paper records a case of tuberculosis in a sheep weighing 18 Kilos which

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was born and reared under semi-wild conditions in the pro--vince of Bologna, Italy. The lungs were covered with circumscribed recently formed nodules of various sizes, which were semi-opaque, greyish-white in colour, and raised about the surface. The condition on closer examination proved to be tuberculosis complicated by concurrent verminous broncho-pneumonia. The mediastinal glands were greatly enlarged resembling a long cylinder 2.5 cm., in diameter and were stony in consistency. On section the glands showed evidence of caseating necrosis with advanced calcification. Histological examination confirmed the diagnosis of tubercu--losis and acid-fast bacilli were seen in numerous clumps. The spleen was found to be infected, and contained a few round fibrous nodules varying in size between a grain of maize and a millet seed. Giant cells were more numerous in the spleen than the lungs. Apparently cultures were not prepared or steps taken to ascertain the type of tubercle bacillus present.

Bruijel (1933) records in a short note a case of tuberculosis in a cow, believed to have originated from some sheep which were later tuberculin tested with positive results. No details are given of the tuberculous lesions in the sheep.

Harshfield and Roderick (1934) record six cases of spontaneous tuberculosis in sheep in America all due to the avian type of bacillus. Five of these were generalised infections, whilst one was confined to the lungs and associated lymph glands. Calcification was well advanced in the lesions. Experiments were carried out to determine the susceptibility of sheep to the avian type of tubercle bacillus.

In the case of intravenous inoculation with

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filtered normal saline emulsion of tuberculous liver and spleen of a chicken infected with a sheep strain, 2 out of 3 lambs showed macroscopic lesions when slaughtered. The actual dose of organisms in such an experiment is, of course, a matter of conjecture only. Feeding experiments with tuberculous material infected two out of three lambs, whilst contact experiments with tuberculous fowls resulted in 2 infections out of 15 sheep. Sensitisation to avian tubercu--lin of short duration was produced in 20 out of 21 sheep, indicating transitory infections.

The rarity of the disease in the United States is emphasised by the following table which records the statistics from the Bureau of Animal Husbandry of sheep slaughtered under Federal Inspection :-

Year	Sheep and Lambs slaughtered:-	Retained for Tuberculosis.	Condemned for Tuberculosis.
1928.	12,983,841.	1.	1.
1929.	13,768,865.	1.	1.
1930.	15,306,899.	5.	5.
1931.	17,300,432.	3.	3.
1932.	18,659,941.	5.	4.
1933.	17,283,875.	2.	2.

Murphy (1935) reported what appears to be the first case of tuberculosis in a sheep in Ireland. Lesions were found in the lungs, spleen and mammary glands, whilst numerous lymph glands throughout the body were also infected. Fibrosis and calcification were well advanced, and in spite of the extensive distribution of the disease there was no obvious systemic disturbance, and the carcase was in good condition. An emulsion of the lesions was inoculated into a rabbit and a guinea-pig both of which died, on the 69th., and 77th., day respectively, from generalised tuberculosis. The infection was probably bovine, but no cultural charac--teristics are recorded and the dose of organisms inoculated was not known, thus the method of typing is open to criticism.

(B). OVINE TUBERCULOSIS IN UGANDA.

The literature concerning tuberculosis in sheep deals almost entirely with the usual European breeds. The native sheep in Uganda and tropical Africa generally are of the Persian fat-tailed type. They are not woolled and their coats consist of coarse hair. Sheep are kept by most tribes, although goats are the most popular of the smaller domestic ruminants. Generally they are never kept in large flocks, and they graze round the villages during the day and share the native huts at night.

So far as I can ascertain there is no record of tuberculosis in the indigenous African sheep, and the recent discovery of the disease in Uganda is of considerable interest.

Apart from the purely pathological and bacterio--logical standpoint the presence of tuberculosis in sheep and goats raises a question of great significance from the public health point of view, as the relation between man and his domestic animals in tropical Africa is of the closest. The sheep and goats, and sometimes cattle, share the same smoke--laden unventilated huts as the native African with his wife and family.

A tuberculous sheep is capable of coughing a droplet infection over the human occupants of the same dwelling, whilst vice versa a tuberculous human-being will disseminate infection with the greatest of ease over both his human and animal co-dwellers. The question of the relationship between tuberculosis in man and animals will be dealth with in another part of this thesis.

It is quite certain that the native does not recognise tuberculosis as a disease of sheep, although there

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is evidence that the disease is not infrequent among these animals.

One of the most striking features regarding cases of tuberculosis encountered in sheep in Uganda, is the apparent absence of any clinical symptoms of the disease , although at autopsy a very advanced pulmonary infection may be found to exist.

The first case of ovine tuberculosis came to my notice in May, 1934, when Mr. Allan, Veterinary Officer Ankole, reported that a ram in the Government Stock Farm flock at Mbarara had died of what appeared to be generalised tuberculosis. He sent some material for bacteriological examination, and the organism was isolated in pure culture. This case will be dealth with in detail under the heading of "Mbarara Ram strain." As will be seen from the records, the organism isolated from this case proved of very great interest as it turned out to be of the human type.

Later, a further sheep and two goats from the same flock were reported as having died of tuberculosis. Unfortunately I did not obtain material for bacteriological examination, but acid-fast organisms were present in smears from the caseous matter in the lungs, and there seems no doubt that tuberculosis was the cause of death.

At this juncture it was decided to send the entire flock of sheep and goats to the Laboratory for investigation purposes. There were 15 sheep and 8 goats available, and I was impressed by the very fine condition of all the animals which were excellent specimens of the best type of native sheep and goats. It will be observed that this flock came from Ankole, where bovine tuberculosis is extremely frequent.

Double intradermal tuberculin tests, using

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0.1 cc., of Burroughs Wellcome's Bovine Tuberculin, were carried out on the sheep and the results of the test are tabulated below. All the positive reactors either died or were slaughtered, and each case will be dealt with in detail when the bacteriological findings in sheep tuberculosis are encountered.

TABLE SHOWING RESULTS OF DOUBLE INTRADERMAL TUBERCULIN TESTS ON SHEEP FROM MBARARA STOCK FARM.

Animal Number :-	Measurements of Skin in mm. Origi-nal.	24 hours.	48 hours.	72 hours.	Results and Clinical Examination:-
Sheep No.1					
Control :-	2.3	3.5	4.0	4.4	Hot swelling -
Tuberculin:	2.5	4.6	5.7	10.5	Positive.
Sheep No.2					
Control :-	2.5	2.7	2.9	3.0	
Tuberculin:	2.8	5.0	4.0	6.5	Negative.
Sheep No.3					
Control :-	2.0	2.5	2.7	3.0	
Tuberculin:	2.0	3.2	3.6	5.0	Negative.
Sheep No.4					
Control :-	2.0	4.5	3.2	4.1	Hot diffuse
Tuberculin:	2.2	5.1	6.0	12.0	swelling. Positive.
Sheep No.5					
Control :-	2.6	2.7	2.3	3.4	
Tuberculin:	2.9	4.0	3.0	5.8	Negative.
Sheep No.6					
Control :-	2.8	5.0	6.4	3.8	Hot swelling -
Tuberculin:	3.0	3.0	3.5	12.8	Positive.
Sheep No.7					
Control :-	2.0	3.0	3.5	3.0	
Tuberculin:	2.5	4.0	3.9	5.0	Negative.
Sheep No.8					
Control :-	2.9	2.4	2.6	2.5	
Tuberculin:	2.9	5.6	6.7	9.3	Positive.
Sheep No.9					
Control :-	2.5	3.0	3.3	3.0	
Tuberculin:	2.8	4.0	3.5	4.8	Negative.
Sheep No.10					
Control :-	2.5	3.5	3.3	4.0	Hot swelling -
Tuberculin:	3.0	4.4	5.8	10.8	Positive.
Sheep No.11					
Control :-	3.0	3.6	3.3	4.2	
Tuberculin:	2.0	4.5	3.7	5.5	Negative.
Sheep No.12					
Control :-	2.2	2.5	2.5	4.0	Hot diffuse
Tuberculin:	2.0	3.0	4.5	11.7	swelling. Positive.
Sheep No.13					
Control :-	2.3	2.5	3.2	2.5	Hot painful
Tuberculin:	2.5	4.0	5.5	12.0	swelling. Positive.
Sheep No.14					
Control :-	2.8	3.6	3.0	3.9	
Tuberculin:	2.4	4.1	5.9	11.3	Positive.
Sheep No.15					
Control :-	2.5	3.0	3.3	4.6	Hot painful
Tuberculin:	3.1	4.9	7.2	12.7	swelling. Positive.

Apart from the tuberculin tests carried out at the Laboratory, 15 sheep were tested in Kigezi district and 25 in Ankole, when the writer was testing cattle. No reactors were discovered, but the number of tests is too small to express an opinion as to the prevalence of the disease in sheep in these areas; although in Ankole the per--centage of reacting cattle was over 76 %, whilst in Kigezi (intermediate type) it was only 5%.

Twelve sheep were sent to the Laboratory from Bugishu district all of which had been housed in huts with cases of human phthisis pulmonalis. None reacted. In the chapter dealing with the typing of human strains, it will be seen that all the cases of pulmonary tuberculosis in natives which were investigated from this area were caused by the human type of bacillus. All these twelve sheep were examined post-mortem, and the negative tuberculin test was confirmed by the absence of any tuberculous lesions.

DETAILS OF CASES OF TUBERCULOSIS IN SHEEP IN UGANDA.

CASE No. 1.

" Mbarara Ram ".

This sheep was bought from a native by the Veterinary Officer, Ankole, and was herded with the flock of sheep and goats at the Government Stock Farm at Mbarara. It had been living in the hut of a native, but unfortunately no details of the medical history of the previous owner are obtainable. The ram was in excellent condition, but was noticed by the herdsman to be coughing for about 10 days before it was found dead.

Post-Mortem Examination :-

Revealed advanced tuberculosis of both lungs, which were full of tubercles and contained large cavities full of caseous material. The bronchial and mediastinal glands were enlarged and caseous. There were tubercles in the spleen. No marked signs of emaciation were present, and there was an abundance of omental and perirenal fat. I am indebted to Mr. Allan, M.R.C.V.S., Veterinary Officer, Ankole, for the above history and post-mortem findings.

Bacteriological Examination :-

A portion of caseous gland was received at the Laboratory in an advanced state of putrefaction. It was ground up in a Griffith's tube with N/1.NaOH, which was allowed to act for 1 hour at 37°C. Two guinea-pigs were inoculated with 1 cc., of the emulsion, after neutralisation with acid.

One of the guinea-pigs died after 48 hours from septicaemia. The second guinea-pig was killed 47 days later, and showed advanced generalised tuberculosis. Cultures were obtained from the spleen on modified Lowenstein's medium (vide technique) and Dorset egg, both non-glycerinated.

After 3 weeks incubation there was a slight flat dry growth. Early subcultures on to glycerinated media showed little or no improvement in growth, but later subcultures gave a much better growth with definite improvement on the glycerinated medium. After the fifth subculture the eugonic character of growth was definitely established.

Animal Inoculations :-

Owing to the unexpected eugonic culture obtained from this case, a considerable number of animal inoculations were carried out with a view to determining the type of organism present. For the sake of clarity the details are submitted in tabular form :-

(S.C. = Subcutaneous; I.M.= Intramuscular; I.V.=Intravenous.)

Animal.	Route & Dose.	Killed or died.	Period of sur--vival in days	Autopsy.
1. Fowl.	10 mg. I.M.	Killed.	43.	Healthy.
2. Fowl.	2 mg. I.V.	Killed.	43.	Healthy.
3. Rabbit.	10 mg. I.M.	Killed.	225.	Healthy; no sign of T.B.
4. Rabbit.	10 mg. I.M.	Killed.	161.	Good condition. Creamy purulent regional abscess; 2 small tubercles in left lung.
5. Rabbit.	0.01 mg., I.V. 21 days old growth on ox serum.	Killed.	177.	Excellent condition. Increase in weight 110 grms. No T.B.
6. Rabbit.	0.1 mg., 21 days old growth on ox serum.	Killed.	177.	Excellent condition. Increase in weight 266 grms. No T.B.
7. Rabbit.	3 mg. I.V.	Killed.	46.	Greatly emaciated. Miliary T.B. of lungs, liver and spleen.

Continued.

Continued.

(S.C. = Subcutaneous; I.M.= Intramuscular; I.V.=Intravenous.)

Animal.	Route & Dose :-	Killed or died.	Period of sur--vival in days.	Autopsy.
8. Rabbit.	5 mg. I.V.	Killed.	76.	Emaciated. Numerous tubercles in lungs, liver and kidneys.
9. G.-pig.	1 mg. S.C.	Died.	68.	Severe generalised T.B.
10. Young Goat.	10mg. S.C.	Died.	66.	No sign of T.B. Death due to parasitic gastritis. (H. contortus).
11. Young Goat.	10mg. S.C.	Killed.	192.	Good condition. A small encapsulated caseous abscess in adjacent (prescapular) gland. No other sign of T.B.
12. Young Goat.	10mg. S.C.	Killed.	192.	Excellent condition. Enlarged prescapular gland but no caseation.
13. Young Sheep.	10mg. S.C.	Killed.	77.	Poor condition. Numerous H. contortus in abo--masum. No sign of T.B.
14. Young Sheep.	10mg. S.C.	Killed.	77.	Fair condition. Adjacent (prescapular) gland enlarged and contained a small focus of yellow caseous pus. Rest of carcase normal.

Observations on Animal Experiments :-

As pointed out in the chapter on technique, only actively growing cultures not more than 28 days old were used for inoculations. The dose used in rabbits Nos. 7 and 8 was, of course, grossly excessive for typing purposes and was inocula--ted merely to test the pathogenicity of the strain.

Goat No. 11 :- Examination of films prepared from the caseous matter revealed numerous acid-fast organisms up to 3 microns in length. They were all showing a beaded appearance, which was probably degenerative, as efforts to obtain cultures were unsuccessful and guinea-pig inoculations with the caseous material did not set up tuberculosis.

Sheep No. 14 :- Examination of films from the caseous focus in the adjacent gland revealed acid-fast organisms, which on inoculation into a guinea-pig set up tuberculosis, thus proving that the organisms were still available.

Conclusions :-

From cultural characteristics and the results of animal inoculations it would seem that this organism is of the human type.

It is generally accepted that sheep are not susceptible to the human type of the tubercle bacillus, but the number of cases of spontaneous tuberculosis in sheep in which the organism has been studied are extremely few.

Inoculation of this particular strain did not set up the disease in two inoculated sheep, and it would appear that this is a rare case of individual susceptibility. It is unfortunate that no history concerning the health of the native owner is available, but it is known that in Ankole human tuberculosis is common.

In view of the above case the following small experiment was carried out to ascertain if native sheep and goats were normally susceptible to the human type of tubercle bacilli.

AN EXPERIMENT TO TEST THE SUSCEPTIBILITY OF UGANDA SHEEP AND GOATS TO A HUMAN STRAIN OF MYCOBACTERIUM TUBERCULOSAE.

One young goat and one young sheep were inoculated with 10 mg., of a 21 day old culture isolated from a phthisical Muhima, a native of Ankole district. This strain was a typical eugonic human virus non-pathogenic to rabbits.

Sheep :-

This animal died from a heavy infection of Haemonchus contortus 51 days later. On autopsy there was no evidence of tuberculosis except a small caseous focus in the adjacent (prescapular) gland. Films from the caseous matter in the mediastinal and bronchial glands, spleen and liver, showed no acid-fast organisms.

Goat :-

This animal also died of parasitic gastritis after 59 days. The adjacent (prescapular) gland was enlarged and indurated but showed no caseation. The rest of the carcase was free from tuberculous lesions, and films prepared from the glands, spleen and liver, showed no acid-fast bacteria.

It would seem from this small experiment that individual sheep and goats in Uganda are not susceptible to the human strain of Mycobacterium tuberculosae - a result which would be expected, although on one of each species it is impossible to generalise. The experiment is merely recorded.

CASE No. 2.

Two-Year old Ewe :-

This was a ewe about 2 years old with a lamb at foot near to weaning. It came to the Laboratory with the Mbarara flock and was turned out in a paddock with the rest. This case occurr--ed before the tuberculin tests were carried out; it was reported sick on March 2nd. On examination its temperature was 105°F., with rapid and distressed respirations. The mucous membrane showed signs of early cyanosis, and on physi--cal examination of the chest there were signs of consolida--tion over the whole area of both lungs. There was a slight muco-purulent discharge from both nostrils. The animal was in fair condition. The next morning it was found dead.

Post-mortem Examination :-

The macroscopic lesions were confined to the thoracic lymph glands and lungs, the rest of the carcase being normal. The mediastinal glands were greatly enlarged and indurated, measuring about 8 cms., long and 3 cms., broad. On section they were found to be full of fibro-caseous material - hard and firm but showing no calcification.

Lungs : Both lungs were distended. The visceral pleura showed gelatinous exudate tending to become organised, and on the right side, adhering to the chest wall, the pleura was thickened and showed firm finger-like filamentous projections from the surface. On palpation of the lungs there were masses of firm round tubercles, whilst shining through the pleura were numerous masses of caseous material about the size of a six-penny piece. The anterior lobe of the right lung, anterior lobe of the left lung, and anterior portion of the middle lobe of the left lung, showed diffuse red hepatisation which, on section, showed numerous miliary tubercles.

Long section of the entire right lung showed in the base a cavity the size of a walnut approximately, opening into a large bronchus in which was found a mass of creamy muco-purulent material containing caseous flakes. A few similar lesions were also present in the rest of the lung. Generally the lung tissue was reddish in colour, and very granular, containing numerous small purulent foci. In the anterior lobe of the right lung there was a mass of dry caseous material.

In the left lung a large purulent focus was present in the base, showing distinct tendency to cavity formation, the cavity opening into a large bronchus. The pus was soft and more muco-purulent than caseous. Smaller foci were present in the parenchyma of the base. The muco-purulent material had a tendency to a greenish tinge. The bronchial lymph glands were large, indurated and congested. In certain of the foci the pus was distinctly granular and dry. The presence of cavities and the larger lesions gave an uneven or lumpy appearance to the surface of the lungs.

The peribronchial and peritracheal tissues showed a reddish oedematous appearance. There was also acute bronchitis and tracheitis with plugs of muco-purulent or muco-caseous material.

Smears from the caseous matter in the lungs and glands showed numerous acid-fast bacilli, whilst the muco-purulent matter in the trachea was swarming with organisms.

Bacteriological Examination :-

In addition to the inoculation of rabbits and guinea-pigs, direct cultures were made on to modified Lowenstein's medium and Dorset egg. After 6 weeks numerous discrete colonies were visible. Subcultures on to glycerinated and non-glycerinated media showed a typical dysgonic flat dry ground-glass like growth. On the glycerine media there was only a very slight film after 4 weeks' incubation at 37°C.

Animal Inoculations :-

(S.C. = Subcutaneous; I.M.= Intramuscular; I.V.=Intravenous.)

Animal.	Route & Dose:-	Killed or died.	Period of survival in days.	Autopsy.
1. Rabbit.	1cc. emulsion of caseous material I.M.	Died.	99.	Severe local lesion. Lungs: mass of tubercles; kidneys full of raised tubercles.
2. Rabbit.	"	Died.	95.	Severe local lesion. Lungs: mass of tubercles; kidneys, raised tubercles; spleen, few tubercles.
3. G.-pig.	1cc. emulsion of caseous material S.C.	Died.	95.	Acute generalised tuberculosis.
4. Rabbit.	0.01 mg., I.V.	Died.	79.	Severe generalised T.B. Raised tubercles on kidneys.
5. Rabbit.	0.1 mg., I.V.	Died.	38.	Acute generalised miliary T.B.
6. Rabbit.	2 mg. I.M.	Died.	59.	Severe generalised T.B. Loss in weight 775 grms.

Conclusion :-

This appears to be a typical dysgonic bovine strain of normal virulence. The period of survival in rabbit No. 4, viz. 79 days, is difficult to account for, but the remaining inoculations amply demonstrate normal pathogenicity.

CASE No. 3.

Sheep No. 6.

This was a very fine specimen of a castrated native ram in excellent condition. It was positive to the tuberculin test in March, and was slaughtered on April 30th.

Post-mortem Examination :-

The carcase was fat and in excellent condition. The prescapu--lar glands and the hepatic lymph glands were enlarged and firmer than usual. The liver showed 12 small calcified nodules about the size of a linseed, situated below the capsule; and 2 larger encapsulated calcified nodules about the size of a pea, in the substance of the organ. There was no sign of fluke infestation, and nodules appeared to be tuberculous in nature.

Acid-fast organisms were not found in smears from these nodules or from the enlarged lymph glands. The rest of the carcase was normal.

Animal Inoculations, etc. :-

Two guinea-pigs were inoculated with emulsion from the liver tubercles, prepared by grinding them up with a little broth. They were killed 107 days later and were found healthy.

Direct culture also failed and no growth was obtained after 3 months.

CASE No. 4.

Sheep No. 15 :-

This was a barren ewe in excellent condition. It gave a positive reaction to the tuberculin test. It was slaughtered on May 5th., 1935.

Post-mortem Examination :-

The right lung showed a localised pleural adhesion to the thoracic wall. The mediastinal gland was enlarged and indurated and contained a small area of caseo-calcified nodules at the pole.

The retropharyngeal and parotid lymph glands were larger and firmer than normal. In the liver there was one fibrous encapsulated nodule about the size of a pea, and containing yellow caseo-calcareous matter. The rest of the carcase was normal.

Acid-fast organisms could not be demonstrated in films prepared from the caseous material in the mediastinal gland or liver.

Bacteriological Examination :-

A typical dysgonic culture was obtained which showed no improvement on glycerinated media.

Animal Inoculations :-

(1). Guinea-pig inoculated subcutaneously with 0.5 cc., of an emulsion of the caseous material died of generalised tuberculosis 107 days later.
(2). Guinea-pig inoculated subcutaneously with 0.5 cc., of an emulsion of the caseous material died 130 days later from generalised tuberculosis.

(3). Guinea-pig inoculated subcutaneously with 1 mg., of culture died 53 days later from generalised tuberculosis.
(4). Rabbit inoculated intramuscularly with 10 mg., of culture died 40 days later. Post-mortem examination showed severe tuberculosis of the lungs, spleen and kidneys,
(5). Rabbit inoculated with 0.01 mg., intravenously died of generalised miliary tuberculosis 21 days later.

Conclusion :-

This organism fulfils all the criteria of a normal dysgonic bovine strain of standard virulence.

CASE No. 5.

Sheep No. 816 :-

This sheep was slaughtered for food at the Mbarara abattoir. It was in good condition and the mediastinal glands were enlarged and full of caseous material. The rest of the carcase was normal. I am indebted to Mr. W. L. Mackintosh, Veterinary Officer, Mbarara, for this examination.

Bacteriological Examination :-

A piece of caseous gland was received in an advanced stage of putrefaction. Smears revealed numerous acid-fast bacteria. Direct cultures were obtained, and these proved to be dysgonic in character and not improved by the addition of glycerine to the medium.

Animal Inoculations :-

(1). Rabbit inoculated intravenously with 0.01 mg., of a 21 days old culture died 37 days later from acute genera--lised miliary tuberculosis.
(2). Guinea-pig received 1 cc., of an emulsion of caseous material subcutaneously. It was killed after 99 days. Autopsy revealed numerous tubercles in the lungs. The spleen was a mass of tuberculous tissue, and the lymph glands all enlarged and caseous.
(3). Guinea-pig inoculated subcutaneously with 1 cc., of caseous emulsion was killed 99 days later. Autopsy revealed advanced generalised tuberculosis.

Conclusion :-

A bovine strain of standard virulence.

CASE No. 6.

Sheep No. 8 :-

A ewe about 4 years old. This sheep was positive to the tuberculin test in March, and was slaughtered in August. It was reported as coughing severely for several days before it was killed.

Post-mortem Examination :-

Liver: one tubercle near the periphery of the right lobe.

Lungs: both distended and consisting of innumerable confluent tuberculous abscesses containing greenish-yellow pus, and varying in size up to that of a walnut. The larger abscesses at the base of the lung were tending to cavity formation.

Glands: Mediastinal - enormously enlarged, about 10 cms., by 3 cms., indurated, and consisting of a mass of tuberculous tissue tending to calcification. Mesenteric - all enlarged and some showing small caseous tubercles. Prescapular and precrural - enlarged but not caseous.

Kidneys: 3 tubercles about 2 mm., diameter in anterior pole of left kidney, and 2 tubercles in anterior pole of right kidney.

Mammary gland normal.

Films from lungs and caseous glands showed numerous acid--fast organisms; kidney and liver negative.

Bacteriological Examination :-

Cultures were obtained directly from the caseous material of the lung. After 3 weeks' incubation a flat dry ground-glass like growth was obtained. Subcultures on glycerinated media were dysgonic in nature, but not so marked as a normal strain. In some tubes the growth appeared slightly more profuse, but the difference was not marked.

Animal Inoculations :-

(1). Guinea-pig inoculated subcutaneously with 1 cc., of caseous emulsion died 39 days later from generalised tuberculosis.
(2). Rabbit received 0.01 mg., of culture intravenously died after 22 days from acute generalised miliary tubercu--losis.

Conclusion :-

A bovine strain of standard virulence.

CASE No. 7.

Sheep No. 10 :-

A ewe positive to the tuberculin test in April. Killed for examination on 26-8-35. It aborted during the night of 24-8-35.

Post-mortem Examination :-

Liver: small caseous area about 4 mm., square in the right lobe. Hepatic gland indurated but no caseation.

Lungs: Fibrous pleural adhesions over anterior lobe of left lung. Right lung - Four small tubercles 2 mm., in diameter in the central lobe. Base of left lung showed two prominent circumscribed tubercles about the size of a walnut, and containing dry caseous material. Rest of lungs normal.

Mediastinal gland enlarged and indurated, about 8 cm. x 1.5 cm., and containing numerous calcified foci.

There was also septic metritis and destruction of several cotyledons by necrosis.

Films from lung lesions showed acid-fast bacilli rare; Uterus and mediastianal gland negative.

Bacteriological Examination :-

A typical dysgonic growth not improved by the addition of glycerine to the medium.

Animal Inoculations :-

(1). Two guinea-pigs inoculated with caseous material from the lungs, subcutaneously, died after 54 and 98 days respectively from generalised tuberculosis.
(2). Rabbit inoculated intravenously with 0.01 mg., of a 21 day old culture died after 41 days of generalised miliary tuberculosis.

Conclusion :-

A bovine strain of normal virulence.

CASE No. 8.

Sheep No. 14 :-

A ewe positive to the tuberculin test in April. Killed for examination 23-9-35.

Post-mortem Examination :-

Excellent condition and carcase quite normal except for the liver, which showed a small group of partially calcified yellow tubercles on the diaphragmatic surface of the organ, and two small calcified tubercles about 2 mm., in diameter on the visceral surface of the organ.

Bacteriological Examination :-

Cultures from the liver lesions were obtained, and were dysgonic and not improved on glycerine media.

Animal Inoculations :-

(1). Guinea-pig inoculated with 0.5 cc., of caseous material subcutaneously, was killed after 75 days. Autopsy showed advanced generalised T.B.
(2). Rabbit inoculated intravenously with 0.01 mg., of culture died after 45 days from generalised miliary tuberculosis.

Conclusion :-

A normal dysgonic bovine strain of standard virulence.

CASE No. 9.

Sheep No. 1 :-

This sheep came from Mbarara Stock Farm, and was positive to the tuberculin test. It was destroyed for examination on 20-9-35.

Post-mortem Examination :-

Condition excellent. Mediastinal lymph gland enlarged and indurated, about 6 cm. x 1.5 cm., and full of yellow dry caseo-calcareous matter. Calcification well advanced.

Acid-fast organisms absent on direct examination of smears.

Liver : One small calcified focus about 2 mm., in diameter. Portal glands enlarged and indurated but no caseation. Was carrying a foetus nearly to term. Retromammary lymphatics enlarged and indurated but no caseation. Guinea-pig inocula--tion and cultures taken.

Bacteriological Examination :-

A dysgonic growth not improved by glycerine media.

Animal Inoculations :-

(1). Guinea-pig inoculated with 0.5 cc., of caseous emulsion subcutaneously was killed after 108 days. Autopsy showed advanced generalised tuberculosis.
(2). Rabbit inoculated intravenously with 0.01 mg., of culture died after 66 days. Autopsy showed severe T.B. of lungs and spleen.

Conclusion :-

A dysgonic bovine culture of lower virulence than normal for the one rabbit inoculated.

CASE No. 10.

Sheep No. 12 :-

Ex Mbarara Stock Farm. Age 5 years. Positive to the tubercu--lin test. Destroyed for examination.

Post-mortem Examination :-

Condition excellent. Left lung contained in its substance 6 small calcified tubercles about the size of rice grains. The right lung contained one tubercle about 1 cm., in diameter, near the ventral periphery of the intermediate lobe, contain--ing dry yellow caseo-calcareous matter. In the lung substan--ce there were 12 small calcified tubercles about the size of rice grains, and two tubercles about 2 mm., in diameter. Mediastinal gland enlarged and indurated, about 5 cm., x 1 cm., and contained caseo-calcareous matter.

Acid-fast organisms rare in smears.

Bacteriological Examination :-

A typical dysgonic growth not improved by the addition of glycerine to the medium.

Animal Inoculations :-

(1). Guinea-pig inoculated subcutaneously with 1 cc., of caseous emulsion died 110 days later from generalised tuberculosis.
(2). Rabbit inoculated intravenously with 0.01 mg., of culture died after 43 days of severe generalised miliary tuberculosis.

Conclusion :-

A bovine strain of normal virulence.

CASE No. 11.

Sheep No. 4 :-

Ex Mbarara Stock Farm flock. Positive to the tuberculin test. Destroyed for examination on 20-9-35.

Post-mortem Examination :-

Excellent condition. Small very firm advanced fluke cirrhosis. Portal lymphatics enlarged and indurated, and each containing one small calcified focus each about the size of a wheat grain. Left lung contained one tubercle about the size of a walnut, and full of dry yellow caseous material. Right lung normal. Mediastinal gland enlarged 7 cm. x 1 cm., and indurated, and containing several foci of caseo-calcareous matter.

Acid-fast organisms rare in lung tubercle; absent in mediastinal and portal glands.

Retromammary glands indurated and enlarged but no caseation.

Animal Inoculations :-

(1). Guinea-pig inoculated subcutaneously with 1cc., of caseous material died from generalised tuberculosis 119 days later.
(2). Rabbit inoculated intravenously with 0.01 mg., of cul--ture died after 68 days. Autopsy showed severe T.B. of lungs and spleen.

Conclusion :-

A dysgonic bovine strain of lower virulence than normal for the one rabbit inoculated.

Sheep No. 13 :-

Ex Mbarara. Positive to the tuberculin test in March. Slaughtered on 20-11-35.

Post-mortem Examination :-

Fair condition. One small encapsulated tubercle about the size of a pea in the substance of the right lung containing caseo-calcareous material. Mediastinal gland enlarged and indurated and containing a small caseo-calcareous focus.

Bacteriological Examination :-

A typical dysgonic culture was obtained from the tubercle in the lung.

Animal Inoculations :-

(1). Two guinea-pigs were inoculated subcutaneously with 0.5 cc., of caseous emulsion and killed after 74 days. Autopsy showed severe generalised tuberculosis.
(2). Rabbit inoculated intravenously with 0.01 mg., of culture died 45 days later from severe generalised miliary tuberculosis.

Conclusion :-

A dysgonic bovine strain of standard virulence.

SUMMARY.

(1). The literature on tuberculosis in sheep is reviewed.

(2). The subject of tuberculosis in sheep in Uganda is discussed.

(3). Details are given of 12 cases of tuberculosis in sheep in Uganda, 11 of which were caused by the bovine, and 1 by the human type of bacillus.

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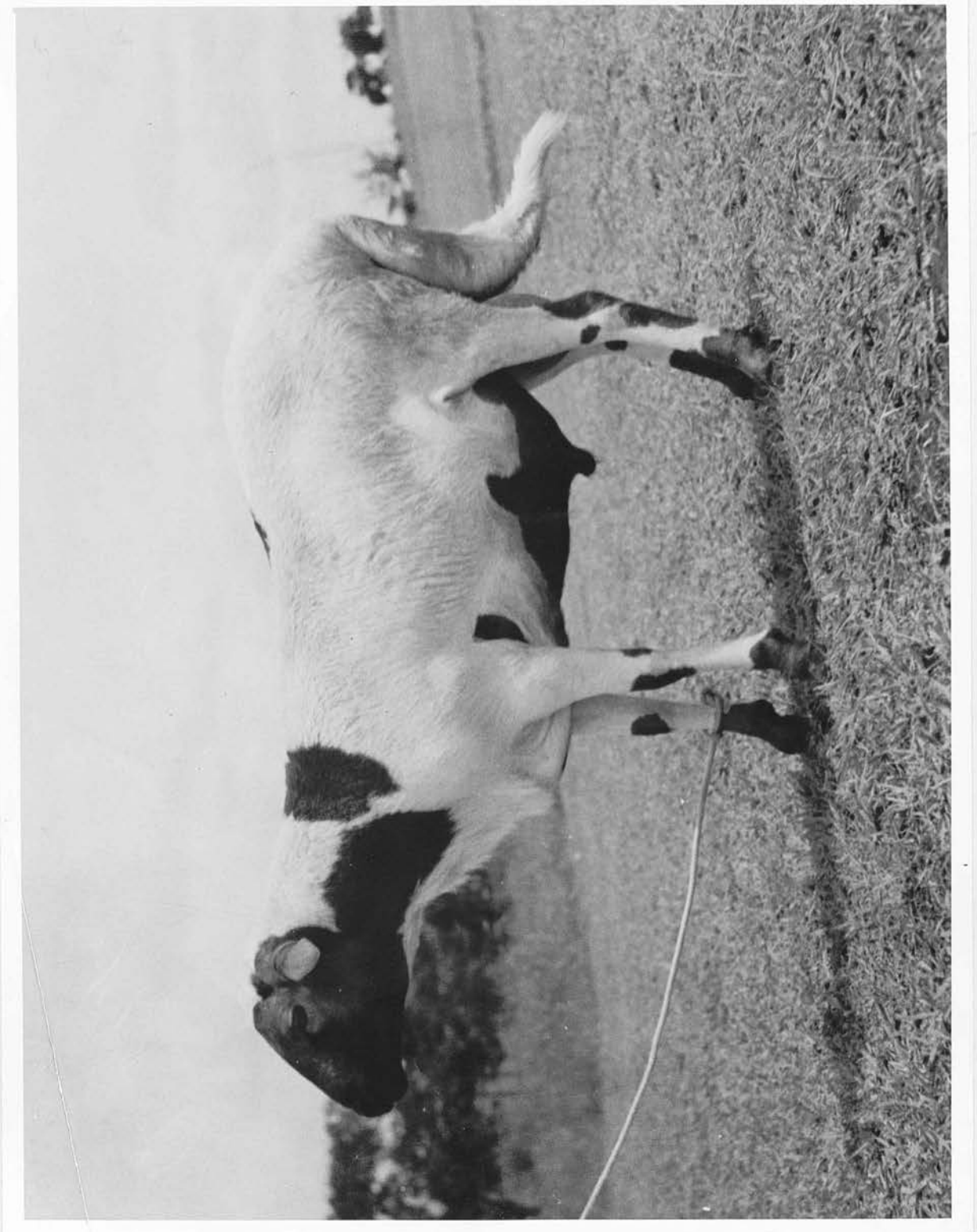
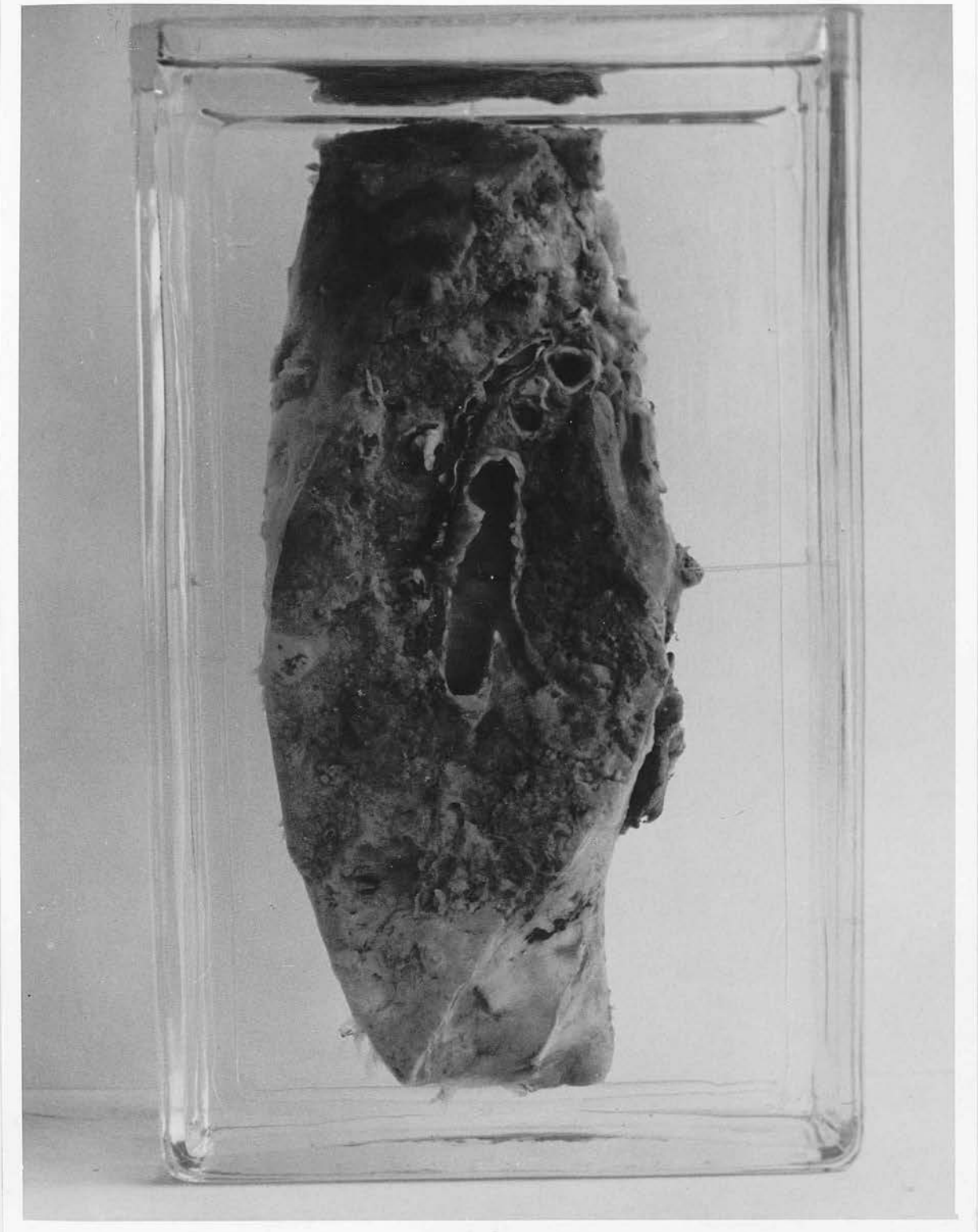
Fig. XI



A TYPICAL SPECIMEN OF THE INDIGENOUS SHEEP IN UGANDA .

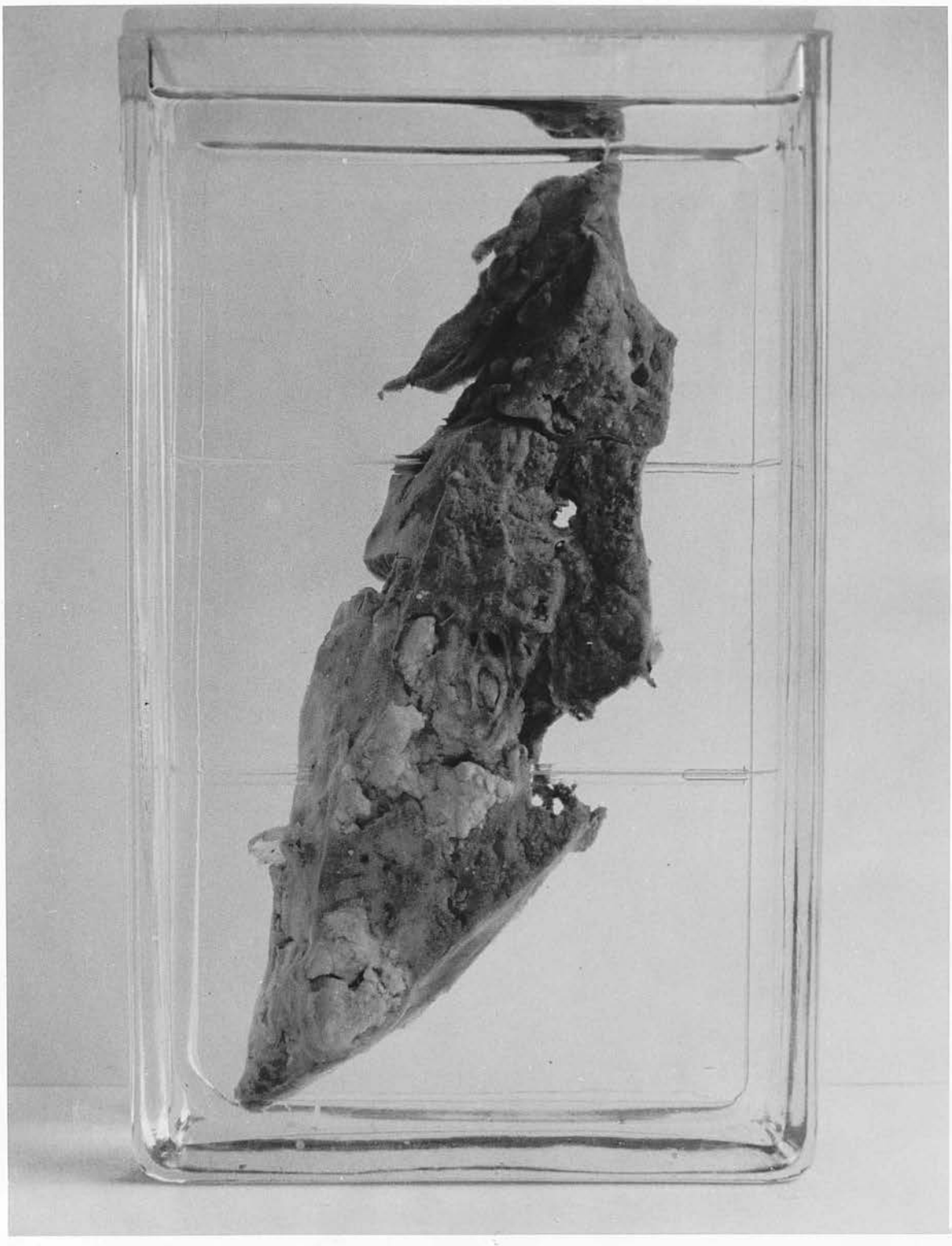
THIS ANIMAL WAS POSITIVE TO THE TUBERCULIN TEST .

Fig XII



A SECTION OF LUNG FROM A SPONTANEOUS CASE OF TUBERCULOSIS IN A SHEEP .

Fig. XIII



A SECTION THROUGH THE LUNG OF A CASE OF SPONTANEOUS TUBERCULOSIS IN A SHEEP (Case No. 2).

PART V

TUBERCULOSIS IN GOATS

(A). REVIEW OF THE LITERATURE.

Spontaneous tuberculosis in goats is only occasionally met with either as a clinical entity or during the course of meat inspection.

Thompson (1904) recorded that in Saxony in the year 1894, out of 1,562 goats slaughtered 0.64% were tuberculous; and in Prussia in 1899, out of 47,705 goats slaughtered 0.41% were tuberculous. In the United States of America, Melvin (1908) records that only one goat out of 46,000 slaughtered under Government supervision was found to be tuberculous. It has been shown by Griffith (1907) that the goat is highly susceptible to inoculation with the bovine organism, even more so than the calf.

Koch (1884) described a case of spontaneous tuberculosis in a goat. Both lungs contained large cavities whilst extensive lesions were present in the spleen and liver. The bronchial glands were greatly enlarged and caseous.

Sluys and Korevaar (1891) reported a case of tuberculosis in a goat which had been brought up on cow's milk. On post-mortem there were lesions of generalised tuberculosis. Infection was considered to have been by the alimentary route because the lesions in the intestines, mesenteric glands and liver, seemed to be older than those in the other organs.

The first authentic case of tuberculosis in a goat in Great Britain was reported by Edgar (1892). He sent enlarged bronchial glands and tuberculous lungs to

(M'Fadyean

M'Fadyean (1892) who confirmed the diagnosis by histo--logical examination. Giant cells and tubercle bacilli were present in sections prepared from the lung tissue.

Bulling (1896) described a case of tubercu--losis in a six-year old goat. The animal was slaughtered and at post-mortem both lungs were adherent to the thoracic pleura. Many small tubercles were found in the lung tissue. Except for an occasional cough the goat showed no symptoms, and was killed on account of poor lactation after having given birth to a healthy kid. Eight other in-contact goats remained free from the disease.

Griffith (1917) recorded a case of sponta--neous tuberculosis in a goat. It had been reared on cow's milk, and was found to react positively to tuberculin. It was slaughtered and post-mortem examination revealed a caseo-calcareous condition of the left bronchial and mediastinal glands. About a dozen tubercles were present in each lung. A circular ulcer was found in a Peyers patch of the small intestine, and the gland draining this was tubercu--lous. The pharyngeal gland and the spleen each contained a calcareo-caseous tubercle. The organism was isolated and proved to be a typical dysgonic bovine type. This appears to be the first case of tuberculosis in goats in which the character of the causal organism has been determined.

Golden (1921) reported tuberculosis in a herd of goats imported into America from Switzerland. Apparently two died from the disease, and tuberculin tests revealed six positive reactors out of 42. These reactors were killed and caseo-calcareous lesions were found mainly in the thoracic lymph glands and lungs, but the spleen and liver were affected in two cases. The type of tubercle bacillus was not determined but the diagnosis was confirmed by Murray (1921) using guinea-pig inoculations.

Little (1924) reported the case of a goat which had shown symptoms of coughing and wasting. It was destroyed in extremis, and on post-mortem examination the lungs, bronchial glands, mediastinal glands and spleen were found to be affected. The diagnosis was confirmed by microscopical examination and guinea-pig inoculation, but the cultural characteristics of the organism and virulence tests were not studied.

Giescu (1924) reported a case of generalised tuberculosis in a six year old goat at Cologne abattoir which had shown no symptoms during life although post-mortem examination showed lesions in the lungs, thoracic lymph glands, liver and kidneys.

Hutyra and Marek (1926) gave a very short account of the clinical manifestations of the disease in goats, and Schroeder and Nocard are quoted as having seen the mammary gland affected.

Griffith (1927 and 1931) recorded a chronic infection in the udder of goats experimentally infected with the avian type of tubercle bacillus. In the first report two goats which were inoculated subcutaneously with avian bacilli showed organisms in their milk 320 days and 20 months later, respectively.

The second goat was the subject of a further report (1931). It had produced kids during the interval, and tubercle bacilli were still being excreted five years later. Further it was shown that kids are resistant to small doses of avian bacilli in the milk taken by the mouth. After five years there was no evidence of a progressive lesion or of destruction of the mammary gland tissue.

Fourie (1928) described a case of tubercu-
-losis in a goat in S. Africa, which appears to have been the first and only case reported from the Union or, in fact,

(from

from any part of Africa. This animal was in a paddock near some tuberculous cattle and probably became infected from them. It apparently showed no clinical symptoms although on post-mortem examination there were extensive lesions in the lungs, whilst the pharyngeal, bronchial and mediastinal glands were also affected. Cavities were present in the lung. The causal organism was of the bovine type.

In Uganda several analagous cases have been seen where there were no clinical symptoms of the disease but extensive lesions on post-mortem examination.

Iyer (1932) found six cases of tuberculosis in goats out of a total of 943 examined. This appears to be the first recorded instance of the disease in Indian goats. The organism appears to have been of the bovine type, but the test dose used him is open to very serious criticism. He inoculated rabbits with 5 mg., of culture intravenously, which would almost certainly prove fatal whether human, bovine or avian bacilli were injected. The amount inoculated was five hundred times the recognised differentiating dose.

Schwabacher (1934) reported a case of spon-
-taneous tuberculosis in a goat 14 months old. The main lesions were found in the right lung, the whole of which was extensively diseased. Cavities containing soft caseous matter were present in the apical and diaphragmatic lobes. The organism was isolated in pure culture and proved to be a typical dysgonic bovine strain of standard virulence.

Bishop, Barnes and Reidy (1934) in America, reported a case of spontaneous tuberculosis in a goat. The animal had access to cattle which were being tested for tuberculosis under the accredited herd plan, and it appeared that its presence was the cause of positive reactors. The goat sickened and was found dead. Post-mortem examination

(revealed

revealed extensive lesions of tuberculosis in the liver, mesenteric lymph glands and lungs. Apparently cultures were not obtained, but rabbits and guinea-pigs were inoculated with emulsions from the lesions and died of generalised tuberculosis. The strain was in all probability bovine, though the method of typing is open to criticism as known doses of organisms were not used for the test inoculations of rabbits.

(B). CAPRINE TUBERCULOSIS IN UGANDA.

As far as tropical Africa is concerned there appears to be no record of tuberculosis among the indigenous goats. The goat in Eastern Africa is ubiquitous in its distribution. They are to be seen near any native dwelling, and appear to be the one animal in tropical Africa which rarely suffers from any disease. They are either tethered to the grass near the huts or taken outside the village by the children to graze. The meat is greatly relished, whilst the skins are used for the making of drums or for clothing.

Since these investigations commenced there is evidence that caprine tuberculosis is far from uncommon in this country.

From the public health point of view, the close contact between these animals and human beings is of great importance. The goats share the huts with the owner and his family, and tuberculosis may quite possibly exist in both the human and animal occupants.

The first case occurred at the Stock Farm at Mbarara during January, 1935, but unfortunately no material was available for bacteriological examination. The Veterinary Officer reports that a billy goat died from pulmonary tuber--culosis, but no details of the autopsy or history of the case could be obtained. Acid-fast organisms were numerous

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in smears from the caseous material in the lungs. The entire herd of 8 goats were sent to the Laboratory for further investigation. The double intradermal test was carried out and the readings and results are tabulated below. All the positive reactors either died or were slaughtered, and the findings will be considered in detail under the individual case records.

TABLE SHOWING RESULTS OF DOUBLE INTRADERMAL TUBERCULIN TESTS ON GOATS FROM MBARARA STOCK FARM.

Animal Number	Measurements of Skin in mm.				Remarks :-
	Orig--inal	24 hours	48 hours	72 hours	
Goat No.1					
Control:-	4.4	6.0	4.9	6.5	Hot and painful.
Tuberculin:	4.4	10.4	10.0	30.5	Positive.
Goat No.2					
Control:-	3.9	5.0	-	-	Discontinued
Tuberculin:	3.9	10.0	-	-	owing to pregnancy
Goat No.3					
Control:-	3.0	4.0	3.5	4.6	Diffuse.
Tuberculin:	3.3	12.8	15.4	19.3	Positive.
Goat No.4					
Control:-	4.3	4.5	3.7	6.0	
Tuberculin:	3.5	6.0	5.0	6.5	Negative.
Goat No.5					
Control:-	3.5	4.6	4.0	4.5	Hot and diffuse.
Tuberculin:	3.5	12.8	10.0	19.0	Positive.
Goat No.6					
Control:-	3.5	4.4	4.5	5.0	Hot and diffuse.
Tuberculin:	3.5	7.0	12.4	27.4	Positive.
Goat No.7					
Control:-	4.2	5.5	4.5	6.7	Hot and painful.
Tuberculin:	4.4	16.3	16.0	25.6	Killed, Positive.
Goat No.8					
Control:-	3.5	4.4	3.0	5.0	
Tuberculin:	3.5	5.0	3.3	6.0	Negative.

Whilst carrying out tuberculin tests in Ankole District I took the opportunity of testing 25 goats by the usual double intradermal method. These animals were picked out at random from around the centre in which I was working and belonged to various natives, represented by four different owners. They browsed round the huts during the day in charge of the children, and were put in the huts with the owner and his family at night. They all appeared healthy and were typical specimens of the native goats in that area. Of the twenty-five, two were found to give a positive reaction. These were bought after considerable trouble from their owner and slaughtered. In both cases autopsy revealed a very advanced tuberculosis of both lungs involving the thoracic lymph glands. These cases will be considered in detail under the individual case records.

Here we have two apparently healthy goats which were in an advanced state of pulmonary tuberculosis living in the same hut as human beings. The type of hut is similar to that shown in the photograph (Fig. XVIII.).

To have discovered two tuberculous goats in the first twenty-five tested, without any selection of any kind, seems to indicate that in Ankole District at any rate caprine tuberculosis must be far from rare.

On the same journey 30 goats were tested in Kigezi District with no reactors. Here the cattle are of the intermediate type and tuberculosis is uncommon, whilst in Ankole bovine tuberculosis is very frequent.

There appears to be a definite relation between tuberculosis in cattle and goats and, as will be seen, the prevailing organism isolated from tuberculous goats is Bovine in type.

DETAILS OF CASES OF TUBERCULOSIS IN GOATS IN UGANDA.

CASE No. 1.

Goat No. 7.

This was a nine months old male goat in excellent condition. It was positive to the tuberculin test in April, and was slaughtered three days later.

Post-mortem Examination :-

The mediastinal glands were enlarged and indurated and contained yellow caseous material with calcification well advanced. The left lung showed one small tubercle in the intermediate lobe about the size of a pea and containing thick creamy purulent material. Acid-fast organisms were present but not numerous. The right lung showed a rather large tubercle about the size of a hazel-nut containing thick creamy pus and acid-fast organisms rare.

Bacteriological Examination :-

Direct cultures from the purulent matter showed, after 6 weeks, a very poor growth consisting of a thin dry film. Sub-cultures on glycerinated media showed no improvement. The growth was typically a dysgonic one.

Animal Inoculations :-

(1). Three guinea-pigs inoculated with an emulsion of purulent material from the lungs died 69, 101 and 113 days later respectively. Post-mortem examination revealed acute generalised tuberculosis in each case.
(2). Rabbit received 0.01 mg., culture intravenously died 36 days later from generalised miliary tuberculosis.
(3). Rabbit received 0.1 mg., culture intravenously died 33 days later from generalised miliary tuberculosis.

Conclusion :-

Bovine strain of standard virulence.

CASE No. 2.

Goat No. 1.

A castrated male in excellent condition. Positive to the tuberculin test in April, and slaughtered 3rd.,May 1935.

Post-mortem Examination :-

The only lesions of tuberculosis were found in the mediasti--nal glands and right lung. The former were enlarged and indurated and full of caseo-calcareous matter whilst the lung showed one encapsulated tubercle the size of a large pea containing dry caseous matter, and a smaller tubercle also caseous. Acid-fast bacilli were absent in the mediasti--nal gland and very rare in the lung lesions.

8.

Bacteriological Examination :-

A typical dysgonic growth was obtained by direct culture from the nodule in the lung. The culture on glycerinated medium was extremely poor.

Animal Inoculations :-

(S.C. = Subcutaneous; I.V. = Intravenous.)

Animal.	Route & Dose.	Killed or died.	Period of Survival in days.	Autopsy.
1. G.-pig.	0.5 c.c. caseous emulsion S.C.	Died.	109.	Generalised T.B.
2. "	"	"	111.	" "
3. Rabbit.	"	Killed.	153.	Small collection of tubercles at site of inocula--tion. A few tubercles in lungs and on parietal pleurae. 2 raised tubercles in left kidney.
4. Rabbit.	0.01 mg., culture I.V.	Died.	23.	Generalised miliary T.B. Loss in weight 430 gm.
5. "	0.1 mg., culture I.V.	"	24.	Generalised miliary T.B. Loss in weight 570 gm.

Conclusion :-

A dysgonic bovine strain of standard virulence.

CASE No. 3.

"Kigungu" Goat.

This was an ordinary male goat bought near Entebbe in December, 1934. It was kept with the healthy goat herd in an area of the laboratory farm where no case of tuberculosis had occurred. It was found dead on May 9th., 1935.

Post-mortem Examination :-

The carcase was emaciated and there was evidence of advanced tuberculosis.
Left Lung : On superficial examination there was a mottled appearance due to scattered firm abscesses up to the size of a walnut, greyish in colour, and surrounded by a reddish--purple consolidated area showing through the visceral pleura. On section these nodules were seen to be composed of dryish (yellow

yellow lardaceous caseous material. These abscesses were scattered throughout the substance of the lung.

Right Lung : The anterior and cardiac lobes were very similar in appearance to the left lung. The main lobe was entirely excavated by a large abscess which contained a curdled yellow milk-like fluid, though near the walls of the abscess the liquid was more inspissated and flaky. The remains of broken down lung tissue and branches of bronchi were found projecting from the wall of the cavity. None of the lesions showed any tendency to calcification.

Bronchial and Mediastinal glands : Greatly enlarged and surrounded by a gelatinous oedema and showed several large soft caseous centres. Calcifications not apparent.

Spleen: Showed one large nodule about the size of a walnut near the hilus, and projecting about 5 mm., above the surface of the organ. Both lungs, especially the right, showed considerable degrees of congestion.

Microscopical examination of caseous matter in the glands and lungs and abscess fluid revealed numerous acid-alcohol--fast organisms about 2 - 3 μ long.

Bacteriological Examination :-

A culture was obtained directly from the caseous matter of the lung lesions by the usual technique. On sub-culturing on glycerinated and non-glycerinated media a good flat dry growth, with a ground glass-like surface, was obtained on the plain medium, whilst on the glycerinated medium no growth was at first obtainable. Later sub-cultures showed a very slight growth on glycerine medium after 4 weeks' incubation.

Animal Inoculations :-

(S.C.=Subcutaneous; I.M.=Intramuscular; I.V.=Intravenous.)

Animal.	Route & Dose.	Killed or died.	Period of Survival in days.	Autopsy.
1. G.-pig.	0.5cc. S.C. caseous emulsion.	Died.	37.	Generalised T.B.
2. "	"	"	74.	" "
3. Rabbit.	1cc. caseous emulsion I.M.	Died.	109.	Severe tuberculo--sis of lungs and raised tubercles on kidneys.
4. G.-pig.	1mg. culture S.C.	Died.	58.	Generalised T.B.
5. Rabbit.	10 mg. culture I.M.	Died.	94.	Very emaciated. Loss in weight 604 gms. Large abscess at site of inocu--lation. Severe T.B. of lungs. Raised tubercles in kidneys.
6. Rabbit.	0.01 mg. culture I.V.	Died.	43.	Severe generalised miliary T.B.

Conclusion :-

A dysgonic bovine strain slightly below standard virulence for rabbits.

CASE No. 4.

Goat No. 6.

This was a female goat brought from Mbarara. It reacted to the tuberculin test in April. On 16-7-35 it was reported sick. Clinical examination showed a temperature of 105° F. Pulse very rapid and thready, coat staring. Palpation of the lungs revealed scattered areas of dullness with hyper--resonance in places. Auscultation showed marked bronchial roles. Breathing was very rapid with signs of dyspnoea, whilst the mucous membranes were cyanotic. On 17-7-35 the animal was obviously dying and was destroyed by bleeding.

Post-mortem Examination :-

The animal was in poor condition but by no means emaciated. On opening the thorax the left lung showed marked congestion of the anterior lobe, which on cutting revealed a mass of caseous tuberculous substance intersected by interstitial tissue. The posterior lobe showed no general congestion, but contained numerous tubercles scattered throughout the paren--chyma varying in size from a few mm., to 1 cm., in diameter.

There was a small localised patch of fibrinous pleurisy adhering to the chest wall. The mediastinal glands were enormously enlarged, 10 x 4 cms., and consisted of a mass of dry caseous material with commencing calcification. The bronchial glands were similarly enlarged and caseous and about 4 cms., in diameter.

The right lung showed on the pleura a large patch, 20 x 15 cms., of localised pleurisy with adhesions to the chest wall. There were numerous tubercles showing through the pleura. On section there was marked hyperaemia and three large cavities full of soft caseous matter mixed with mucous and communi--cating with the main bronchus. The caseous matter was greenish-yellow in colour.

Spleen : On palpation revealed about a dozen firm tubercles scattered throughout the substance of the organ. The tubercles were about the size of a small pea, and contained dry caseous material.

Liver : Was small and firm and full of scattered agglomerates of caseous tubercles, some of which were tending to calcify (see Fig.). The hepatic glands were greatly enlarged and consisted of a mass of dry caseous material. They were 3 - 4 cms., in diameter. The mesenteric glands were all greatly enlarged, and consisted of dry caseous material which in some cases showed early calcification.

The mammary gland was not lactating and showed no tuberculous lesions. The retro-mammary gland was indurated and enlarged but showed no caseation. The retropharyngeal glands were enlarged and contained several firm tubercles. The rest of the glands were normal. The heart was small and the myocardium

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showed signs of atrophy, and was pale and flabby.

Microscopical examination of the caseous matter from the lungs showed very rare acid-fast bacilli.

Bacteriological Examination :-

The organism was isolated directly from the caseous matter in the lung and proved to be a typical dysgonic strain. The growth on glycerinated medium was extremely poor.

Animal Inoculations :-

(S.C.= Subcutaneous; I.V.= Intravenous.)

Animal.	Route & Dose.	Killed or died.	Period of survival in days.	Autopsy.
1. G.-pig.	1cc. of caseous emulsion S.C.	Died.	78.	Generalised T.B.
2. "	"	"	103.	" "
3. Rabbit.	0.01 mg., culture I.V.	"	28.	Acute generalised miliary T.B.

Conclusion :-

A normal dysgonic bovine strain of standard virulence.

CASE No. 5.

Goat No. 5.

From Mbarara. Positive to the tuberculin test in April. Killed for examination 17-7-35.

Post-mortem Examination :-

Excellent condition. Mediastinal gland enlarged and on section showed a mass about 3 x 1 cms., of dry caseous matter with commencing calcification. In the left lung near the periphery (ventral edge), there were a few firm caseous nodules. Left retropharyngeal gland showed one caseous tuber-cle. Rest of the carcase normal.

Microscopical examination of caseous matter showed no acid-fast organisms. Two guinea-pigs inoculated after treatment with NaOH and neutralising, and cultures made.

Bacteriological Examination :-

A single colony was obtained by direct cultural methods, which on glycerinated and non-glycerinated media gave a typical dysgonic growth.

Animal Inoculations :-

(S.C.= Subcutaneous; I.V.= Intravenous.)

Animal.	Route & Dose.	Killed or died.	Period of survival in days.	Autopsy.
1. G.-pig.	1cc. emulsion of caseous gland S.C.	Died.	117.	Generalised T.B.
2. "	1cc. emulsion of caseous material S.C.	"	139.	" "
3. Rabbit.	0.01 mg., culture I.V.	"	54.	Severe generalised miliary T.B.

Conclusion :-

A typical dysgonic bovine strain. The virulence for this rabbit is somewhat below normal.

CASE No. 6.

Goat No. 3.

Positive to the tuberculin test in April. Killed for exam--ination on 18-7-35.

Post-mortem Examination :-

Female in excellent condition. The only lesion was in the mediastinal gland which was enlarged and on section showed a mass of dry caseous matter. Calcification had not commenc--ed.

Acid-fast organisms rare. Two guinea-pigs inoculated and cultures made.

Bacteriological Examination :-

A typical dysgonic strain was isolated from the caseous matter of the mediastinal gland.

Animal Inoculations :-

(S.C. = Subcutaneous; I.V.= Intravenous.)

Animal.	Route & Dose.	Killed or died.	Period of survival in days.	Autopsy.
1. G.-pig.	1cc. emulsion of caseous material S.C.	Killed.	66.	Adjacent glands and spleen tuberculous.
2. "	"	Died.	87.	Generalised T.B.
3. Rabbit.	0.01 mg., culture I.V.	Died.	39.	Severe generalised miliary T.B.

Conclusion :-

A bovine strain of normal virulence.

CASE No. 7.

Goat No. 572.

This goat was slaughtered for food at Mbarara abattoir. The only lesion of tuberculosis was caseation of the mediastinal gland. Films prepared from the caseous material were sent to the Laboratory for examination and revealed acid-fast organisms. Two duplicate slides were washed with sterile broth and inoculated into 3 guinea-pigs.

One guinea-pig showing a large superficial inguinal (adjacent) gland was killed 43 days later, and pure cultures were obtained from the caseous gland.

The other two guinea-pigs did not become infected.

A series of small raised dry colonies were seen on the medium after 54 days incubation. Sub-inoculation on glycerinated and non-glycerinated media showed a flat dry growth with ground glass-like surface, rather better on the glycerinated medium, after 41 days.

Animal Inoculations :-

(1). A guinea-pig inoculated with 1 mg., of culture subcu--taneously died 67 days later. Post-mortem examination revealed generalised tuberculosis.
(2). A rabbit inoculated with 0.01 mg., of culture intra--venously died 75 days later from severe generalised miliary tuberculosis.

Conclusion :-

A bovine strain rather below average virulence for the rabbit.

CASE No. 8.

Goat No. 940.

This goat was submitted to the tuberculin test with 24 others in Ankole and gave a positive reaction. These were chosen at random from owners in the vicinity of my camp. This animal was housed at night with 8 other goats in the hut with the owner and his family. One other goat was also positive to the test. The Medical Officer, Ankole, very kindly examined the owner and his wives and family, and found them free from clinical signs of tuberculosis.

The tuberculin test (double intradermal) gave the following readings :-

	Skin Measurements in mm. (Original)	(24 hrs)	(48 hrs)	(72 hrs)	Remarks.
Control:-	3.8	5.0	4.5	6.0	Hot and painful.
Tuberculin:-	4.0	17.5	19.0	24.0	

The goat, which appeared perfectly healthy, was purchased and slaughtered for examination.

Post-mortem Examination :-

The carcase was in good condition and well nourished. Both lungs were distended and congested, and were filled with numerous abscesses varying in size from a millet seed up to 3 - 4 cms., in diameter. The abscesses contained a greenish--yellow fluid consisting of caseous material. There was a tendency to large cavity formation in the apices of both lungs.

The pleurae showed a fibrinous inflammation with adhesions to the chest wall. The spleen contained one tubercle about the size of a small pea. Acid-fast organisms were numerous in the pus from the lungs, but very rare in the spleen tubercle.

The uterus was gravid and contained two foetuses near to term.

Bacteriological Examination :-

A pure culture giving quite a good growth was obtained from the purulent material, which was sub-inoculated on glycerin--ated and non-glycerinated media. A flat dry growth was seen after a month's incubation, which tended to be rather better on the glycerinated medium.

Animal Inoculations :-

(S.C. = Subcutaneous; I.V.= Intravenous.)

Animal.	Route & Dose.	Killed or died.	Period of survival in days.	Autopsy.
1. G.-pig.	1cc. caseous emulsion S.C.	Killed.	113.	Generalised T.B.
2. Rabbit.	0.01 mg., culture I.V.	Died.	61.	Severe generalised miliary T.B.
3. "	"	"	57.	"

Conclusion :-

A bovine strain below standard virulence for the rabbit.

CASE No. 9.

Goat No. 939.

This was a young female goat the weaned kid of Case No. 8. The history is exactly the same as for Case No. 8. It reacted to the double intradermal tuberculin test as follows :-

	Skin Measurements in mm. (Original)	(24 hrs)	(48 hrs)	(72 hrs)	Remarks.
Control:-	3.5	3.5	4.0	5.5	Hot diffuse swelling.
Tuberculin:-	3.4	6.3	8.9	18.0	

This goat appeared perfectly healthy and was purchased and slaughtered.

Post-mortem Examination :-

Excellent condition. The lesions were confined to the thoracic cavity. There was marked fibrinous pleurisy with adhesions.

The mediastinal glands were enlarged and full of caseous matter. Both lungs were congested and distended and on section showed innumerable small translucent abscesses scattered throughout the parenchyma. At the apices of both lungs there was a large abscess about 4 cms., in diameter, breaking down with cavity formation.

Numerous acid-fast organisms were present in the purulent material of the abscesses.

Bacteriological Examination :-

A dysgonic growth, not improved by glycerine, was obtained directly from the purulent matter in the lungs.

Animal Inoculations :-

(1). Rabbit received 0.01 mg., of culture intravenously and died of acute miliary T.B. of the lungs and spleen 21 days later.
(2). Guinea-pig received 0.5 c.c., emulsion of purulent material subcutaneously died 77 days later from generalised tuberculosis.

Conclusion :-

A bovine strain of standard virulence.

CASE No. 10.

Goat No. 2.

This goat was not tested in April as she was within a day or two of parturition. She gave birth to two healthy kids on 26-4-35, and was tested on 23-7-35. It gave a positive reaction and was destroyed.

Post-mortem Examination :-

Excellent condition. A perfectly normal carcase with the exception of a small tubercle about 4 mm., in diameter in the substance of the intermediate lobe of the left lung. This contained a yellow caseo-calcareous substance.

Films showed no acid-fast organisms.

Bacteriological Examination :-

A typical dysgonic growth was obtained after 35 days incuba--tion, which was not improved on glycerinated medium.

Animal Inoculations :-

(1). Guinea-pig inoculated subcutaneously with caseous matter from the lung lesion was killed after 95 days. Autopsy showed advanced generalised tuberculosis.

(2). Rabbit inoculated with 0.01 mg., of 21-day old culture intravenously died after 32 days of severe generalised miliary tuberculosis.

Conclusion :-

A bovine strain of standard virulence.

SUMMARY.

(1). The literature on tuberculosis in goats is reviewed.

(2). The subject of tuberculosis in goats in Uganda is discussed.

(3). Details are given of 10 cases of tuberculosis in goats in Uganda, all of which were caused by the bovine type of bacillus.

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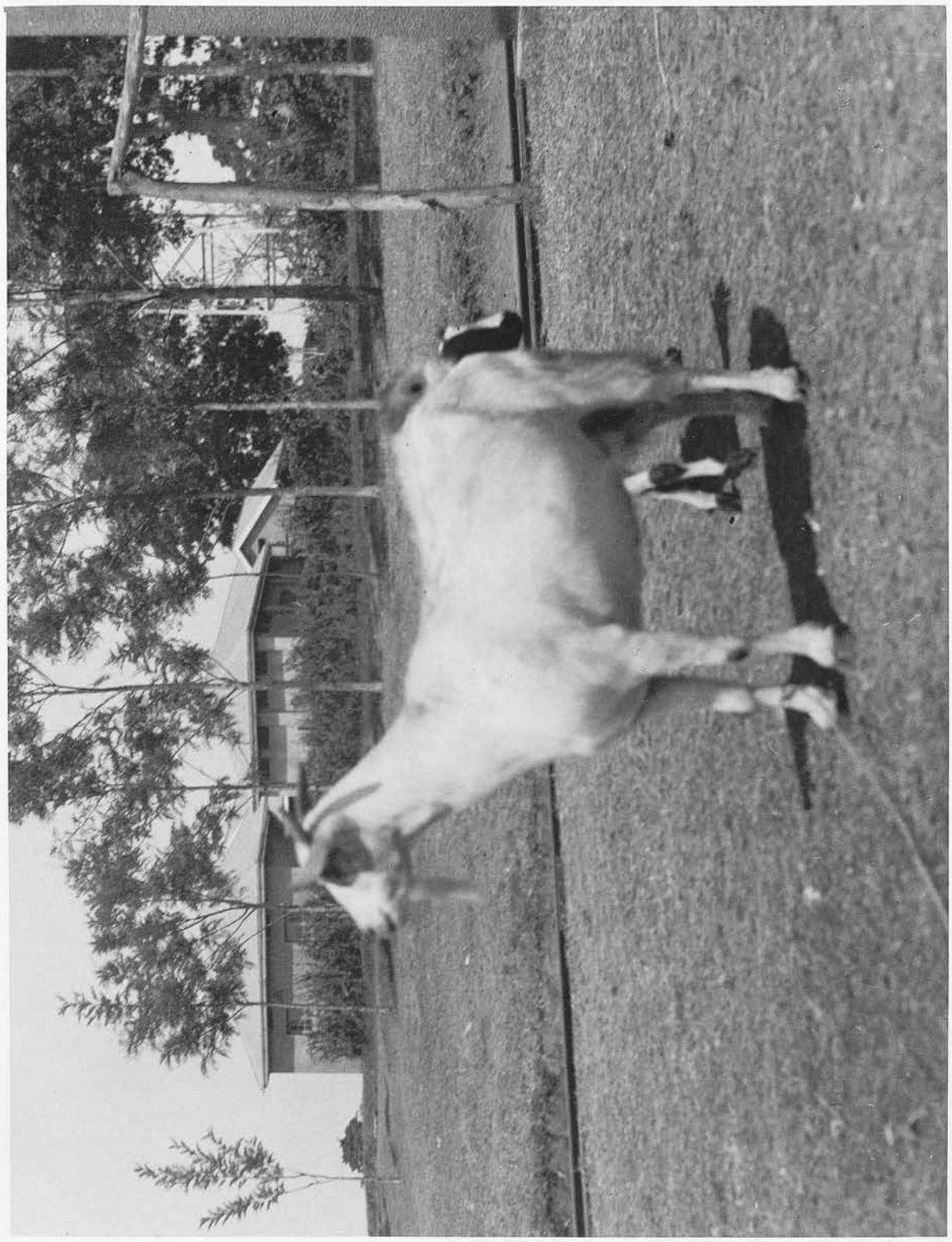
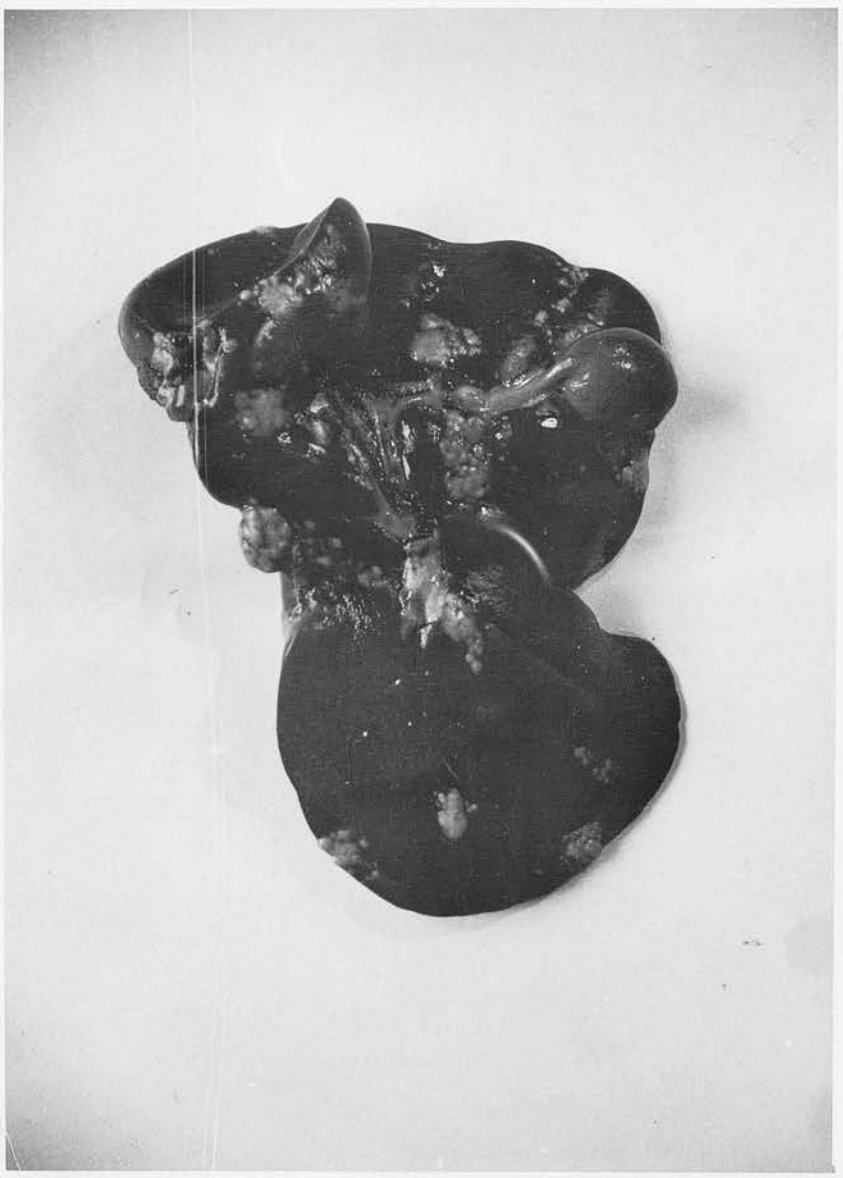
Fig. XIV



A GOOD SPECIMEN OF A NATIVE GOAT.

This animal was positive to the Tuberculin test and a bovine organism was recovered (see Goat No.2) .

Fig. XV



LIVER FROM A SPONTANEOUS CASE OF TUBERCULOSIS IN A GOAT (Case No.4) .

PART VI

THE RELATION BETWEEN HUMAN AND BOVINE TUBERCULOSIS IN UGANDA.

Reliable figures in regard to the incidence of human tuberculosis in Uganda are extremely difficult to obtain as, even at the present time, the majority of sick natives are never seen by a Medical Officer and do not seek medical aid.

The following statistics taken from the Annual Reports of the Uganda Medical Department show the number of cases of tuberculosis actually seen at Government Hospitals and Dispensaries :-

Year	Pulmonary	Non-Pulmonary	Total
1910.	22	-	22
1911.	50	-	50
1912.	26	-	26
1913.	37	-	37
1914.	21	-	21
1915.	11	-	11
1916.	14	-	14
1917.	15	-	15
1918.	8	-	8
1919.	16	-	16
1920.	22	-	22
1921.	14	-	14
1922.	-	-	-
1923.	29	-	29
1924.	48	-	48
1925..	34	-	34
1926.	113.	108(1)	221
1927.	162	46	208
1928.	212	40	252
1929.	316	63	379
1930.	254	70	324
1931.	299	64	363
1932.	588	106(2)	694
1933.	719	89(3)	808
1934.	900	107	1007

(1). Includes 70 cases of T.B. of the lymphatic system which is probably erroneous.
(2). Includes 27 cases of T.B. of the skin which is greatly in excess of other years.
(3). Includes 18 cases of chronic disseminated T.B. which is probably unreliable.

It will be seen that, at any rate in recent years when figures are probably more reliable, the number

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of pulmonary cases far exceeds the non-pulmonary cases.

It is an accepted fact that the bovine type of tubercle bacilli is rarely found in cases of phthisis pulmonalis. The statistics quoted by Griffith (1930) show that in England and Wales only 1% of all phthisis cases were caused by the bovine type of bacillus, in Scotland 1.4%, and Foreign statistics (Mollers, 1928) 0.4%.

Investigations into the type of tubercle bacillus found in pulmonary tuberculosis have been carried out ever since Koch made the announcement in London in 1901 that the bovine type of bacillus did not produce serious disease in man, and that special precautions need not be taken against it. Later, at the Washington Congress in 1908, Koch withdrew this extreme view, but he maintained that no satisfactory proof had been furnished that the bovine type could produce pulmonary tuberculosis.

Griffith (1914), working for the British Royal Commission, was the first to demonstrate that the bovine bacillus could produce pulmonary tuberculosis, and he published an account of three cases.

Wang (1916) reported a single case in Edinburgh.

Griffith (1930) reviewed the investigations carried out up to that date on bovine tubercle bacilli occurring in the sputum of phthisical persons in Britain and other countries. The following tables are reproduced from this review :-

ANALYSIS OF THE EXAMINATION OF SPUTUM IN ENGLAND.

Authors.	Date of Publi--cation.	No. of cases.	Classification of Cultures.		
			Eugonic Human.	Dysgonic Human.	Bovine.
Cobbett.	1908.	2.	2.	-	-
Griffith.	1911.	29.	27.	-	2.
Bulloch.	1911.	23.	23.	-	-
Griffith.	1914,16.	110.	108.	2.	-
"	1920.	17.	16.	1.	-
"	1930.	146.	145.	-	1.
	Total:	327.	321.	3.	3.

ANALYSIS OF THE EXAMINATION OF SPUTUM IN SCOTLAND.

Authors.	Date of Publi--cation.	No. of cases.	Classification of Cultures.			
			Eugonic Human.	Dysgonic Human.	Bovine.	Mixed H. & B.
Griffith.	1914.	73.	71.	1.	1.	-
Wang.	1916.	29.	28.	-	1.	-
Munro and others.	1924.	100.	97.	-	2.	1.
Munro.	1930.	150.	143.	-	7.	-
Munro.	Unpubli--shed.	116.	110.	-	6.	-
	Total:	468.	449.	1.	17.	1.

ANALYSIS OF THE RESULTS OBTAINED

IN THE EXAMINATION OF SPUTUM IN FOREIGN COUNTRIES.

Authors.	No. of cases.	Classification of Bacilli.		
		Human.	Bovine.	Mixed.
Various.	86.	85.	-	1.
Dieterlen.	50.	50.	-	-
Kitasato.	152.	152.	-	-
Park & Krumwiede.	296.	296.	-	-
Mollers.	51.	51.	-	-
Janeso & Alfer.	5.	5.	-	-
Kossel.	46.	45.	-	1.
Weber & Dieterlen.	9.	9.	-	-
Lindemann.	41.	40.	-	1.
Pawan.	40.	40.	-	-
Poire & Carranza.	150.	150.	-	-
Total:-	926.	923.	-	3.

Lange (1931 & 1932) reported 40 cases of pulmonary tuberculosis occurring amongst dairy farm workers in Germany. Of these 8 were found to be due to the bovine organism.

Lange is of the opinion that these cases are due to exogenous air-borne infection (i.e., by inhalation) occurring in adult life, the vehicle of infection being either droplets coughed out by the cattle with pulmonary lesions, or the dust in the hides of the cattle.

This opinion is interesting in view of the close contact between cattle, many of which are tuberculous, and human beings in certain native tribes in Uganda, where pulmonary tuberculosis is not infrequent.

Griffith and Munro (1932) reported three further Scottish cases of bovine phthisis out of 80 speci--mens of sputum examined, and pointed out that up to that time, out of 548 cases of phthisis in Scotland, 21 (3.8%) had yielded bovine bacilli in one instance associated with the human type.

Cumming and Foster (1933) reported 14 new English cases of pulmonary tuberculosis due to the bovine organism. Five of these cases occurred in patients who had been much in contact with cattle.

In the same year Cumming (1933) found 4 bovine cases out of 14 phthisical patients who had come much in contact with cattle.

Wilcox (1934) working in the neighbouring territory of Tanganyika, isolated 9 strains of Mycobacterium tuberculosae from African natives, all of which proved to be of the human type.

Munro and Walker (1935) report a case of pulmonary tuberculosis due to the bovine type of bacillus,

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and give details of the autopsy findings.

Griffith and Munro (1935) record the histor--ies of two families of which several members suffered from tuberculosis, the infecting organism being bovine in type. In one family infection probably occurred in each individual as the result of drinking infected milk. In the other family evidence suggests that the bovine strain of infection was transmitted from a man to his wife by contact.

Tobiesen, Jensen and Lassen (1935) working at the State Serum Institute at Copenhagen, have demonstrated the bovine type of tubercle bacillus in 26 cases of pulmonary tuberculosis between February 1931 and July 1933. It appears that in Denmark which, of course, is essentially an agri--cultural dairy country, bovine phthisis is common. Only three of the 26 patients denied ever having drunk unboiled milk, whilst thirteen of them consumed it regularly. It is interesting to note that in only one case were other infec--tions of tuberculosis found in the patient's home, and this proved to be an infection with the human type of organism.

Griffith and Smith (1935) in a recent investigation in North-East Scotland have determined the type of tubercle bacillus in the sputum of 103 cases of phthisis pulmonalis. Of these, 90 proved to be of the human type, and 13 of the bovine type. The bovine strains were all dysgonic and highly virulent for rabbits.

On reviewing the literature it is evident that bovine bacilli in the sputum of cases of pulmonary tubercu--losis are not the bacteriological curiosities they were 10 years ago.

In Uganda, the position as regards tuberculosis in cattle has already been discussed, and it has been pointed out that the incidence is particularly high in the Ankole cattle.

Tuberculosis is also common in the Bahima people who graze these cattle. Owing, however, to the Bahima's aversion to seeking medical aid, the number of cases of tuberculosis actually seen are relatively few, but there exists no difficulty in collecting sputum containing tubercle bacilli if the kraals are visited and people suffering from " akakololo " are prevailed upon to provide specimens. Akakololo merely means a cough in the Luhima language, but it is quite certain that a number of such cases, which are extremely numerous, are in fact pulmonary tuberculosis.

In cases where haemoptysis is present the condition is differentiated by the name " machwamba " .

Here then, in Ankole, exists a state where tuberculosis is common both in human beings and cattle, and the contact between the two is of the closest. These Hamitic pastoral people live entirely on the milk and blood of their cattle, and the whole sociological structure of the tribe is intimately bound up with their stock.

The blood is drawn from the jugular vein of a bullock by means of a specially prepared arrow and is mixed with the milk which is never boiled.

Obesity is considered as a sign of beauty in females, and women are literally fattened up on milk. Tuberculosis is, however, as far as I can discover, much commoner in men than in women or children.

Non-pulmonary tuberculosis does not appear to be of frequent occurrence. The custom of several individuals using the same sucking-tube, or " oluseke ", for drinking beer, and the generally filthy conditions in which they live in small huts with no ventilation, all tend to foster spread of the disease.

My first hypothesis was that, if these people suffered to any extent from " Bovine " phthisis, then the

(conditions

conditions for cattle-man-cattle infection would be almost ideal and a vicious circle of infection established.

It was with this possibility in mind that I commenced to isolate and type strains of tubercle bacilli collected from these people. As will be seen later, when the results of typing are discussed, not a single strain of bovine virus was isolated from the Bahima. It was not possible to study large numbers of strains from this one tribe, owing to the difficulty of collection, so the work was extended to cover as many cases as possible in the whole Protectorate.

As this was an entirely new field of investi--gation, and nothing was known bacteriologically regarding tuberculosis in Uganda, the results of the typing of strains are recorded in some detail in tabular form below.

The different tribes are then discussed, when the results are grouped under tribal headings. It will be recalled at this stage that the tubercle bacilli isolated from cattle in Uganda all appear typical bovine strains of normal virulence for rabbits.

TABLE SHOWING STRAINS OF MYCOBACTERIUM TUBERCULOSAE ISOLATED FROM HUMAN CASES IN UGANDA.

(N.B. All patients were Males and cases of Pulmonary Tuberculosis except where otherwise stated.)

(S.C. = Subcutaneous; I.M. = Intramuscular; I.V. = Intravenous.)

No:-	TRIBE.	HISTORY.	CULTURAL CHARACTERISTICS.	ANIMAL INOCULATIONS.					TYPE.
				Animal.	Inoculum.	Killed or died.	Period of survi-val in days.	AUTOPSY.	
1.	Mukiga.	Cattle-owning tribe; working in Kampala.	Early growths on glycerine egg poor; later subcultures typically eugonic.	G.-pig.	Sputum, S.C., 9-3-34.	Killed, 12-4-34.	33.	Early generalised T.B.	
				Rabbit.	0.01 mg., culture I.V.	Killed.	48.	Healthy.	
				Rabbit.	10 mg., culture I.M.	Killed.	116.	Healthy. Small retrogressive abscess at site of inocula-tion.	Human.
2.	Muzinga.	Tanganyika native; working in Kampala.	Typical eugonic growth on glycerine egg.	G.-pig.	Sputum, S.C.	Killed.	60.	Advanced generalised T.B.	
				Rabbit.	10 mg., culture I.M.	Killed.	125.	Healthy. Small retrogressive abscess at site of inocula-tion.	Human.
3.	Muhima.	Living in close contact with cattle in kraal.	Poor early growth; later subcultures greatly improved on glycerine egg.	G.-pig.	Sputum, S.C.	Killed.	47.	Advanced generalised T.B.	
				Rabbit.	10 mg., culture I.M.	Killed.	90.	Healthy.	Human.
4.	Muhima.	Living in close contact with cattle in kraal.	Typical eugonic growth greatly improved on glycerine egg.	G.-pig.	Sputum, S.C.	Killed.	45.	Early generalised T.B.	
				Rabbit.	0.01 mg., culture I.V.	Killed.	64.	Healthy.	Human.
5.	Mwiru.	Mbarara Hospital; lives in kraal with cattle.	Thin flat dysgonic growth not improved on glycerine egg.	G.-pig.	Sputum, S.C.	Killed.	45.	Advanced generalised T.B.	
				Rabbit.	0.01 mg., culture I.V.	Died.	64.	Severe generalised miliary T.B.	
				Rabbit.	3 mg., culture I.M.	Died.	196.	Mass of tubercles in lungs and on pleurae. Raised tubercles on kidneys.	Bovine.
6.	Muganda.	No history of contact with cattle.	Typical eugonic growth greatly improved on glycerine egg.	G.-pig.	Sputum, S.C.	Killed.	66.	Advanced generalised T.B.	Human.
7.	Muhima.	Living in close contact with cattle in kraal.	Eugonic, greatly improved on glycerine egg.	G.-pig.	Sputum, S.C.	Killed.	31.	Early generalised T.B.	
				Rabbit.	10 mg., culture I.M.	Killed.	92.	Healthy.	
				Rabbit.	0.01 mg., culture I.V.	Killed.	104.	Healthy.	Human.
8.	Muziba.	Tanganyika native; cattle tribe, working in Kampala.	Typical eugonic growth on glycerine egg.	G.-pig.	Sputum, S.C.	Killed.	30.	Regional glands and generalised T.B. commencing.	
				Rabbit.	10 mg., culture I.M.	Killed.	70.	Healthy. Retrogressive local abscess only.	Human.

Continued.

Continued.

No:-	TRIBE.	HISTORY.	CULTURAL CHARACTERISTICS.	ANIMAL INOCULATIONS.					TYPE.
				Animal.	Inoculum.	Killed or died.	Period of survi--val in days.	AUTOPSY.	
9.	Munaruanda.	Cattle tribe; working in Kampala.	Typical eugonic growth greatly improved on glycerine egg.	G.-pig.	Sputum, S.C.	Killed.	39.	Generalised T.B. commencing.	Human.
10.	Mwiru.	Lived in kraal with cattle.	Flat dry dysgonic growth not improved on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	48.	Generalised T.B. well advanced.	
				Rabbit.	0.01 mg., culture I.V.	Died.	42.	Severe generalised miliary T.B.	
				Rabbit.	0.1 mg., culture I.V.	Died.	38.	Severe generalised miliary T.B.	
				Rabbit.	10 mg., culture I.M.	Died.	150.	Severe generalised T.B. Local abscess lungs, raised tubercles on kidneys and all glands.	Bovine.
11.	Muganda.	In Mulago Hospital. No contact with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	56.	Generalised T.B. advanced.	Human.
12.	Musubi.	Tanganyika native; working in Kampala.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	33.	Early generalised T.B.	Human.
13.	Munaruanda.	Cattle tribe; working in Kampala. History of working with cattle and drinking large quantities of milk.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	54.	Generalised T.B.	
				Rabbit.	10 mg., culture I.M.	Killed.	152.	Healthy.	Human.
14.	Muhima.	Living in kraal with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	42.	Early generalised T.B.	
				Rabbit.	10 mg., culture I.M.	Killed.	119.	Healthy.	Human.
15.	Muhima.	Living in kraal with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	46.	Early generalised T.B.	
				Rabbit.	10 mg., culture I.M.	Killed.	121.	Healthy.	Human.
16.	Muhima.	Living in kraal with cattle.	Early cultures showed poor growth on glycerine and plain egg. Later subcul--tures typical eugonic growth.	G.-pig.	Sputum, S.C.	Killed.	54.	Generalised T.B.	
				Rabbit.	10 mg., culture I.M.	Killed.	118.	Healthy.	
				Rabbit.	0.01 mg., culture I.V.	Killed.	107.	Healthy.	Human.
17.	Mwiru.	Mulago Hospital. No history of contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.

Continued.

Continued.

No:-	TRIBE.	HISTORY.	CULTURAL CHARACTERISTICS.	ANIMAL INOCULATIONS.					TYPE.
				Animal.	Inoculum.	Killed or died.	Period of survi--val in days.	AUTOPSY.	
18.	Muganda.	Mulago Hospital. No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
19.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
20.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
21.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
22.	Munaruanda.	Cattle tribe;working in Kampala. Drinks large quantities of milk.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
23.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
24.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
25.	Arab.	Namirembe Hospital; no history of cattle contact.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
26.	Arab.	Namirembe Hospital; no history of cattle contact.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	66.	Generalised T.B.	Human.
27.	Muganda.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
28.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
29.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	48.	Generalised T.B.	Human.
30.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	70.	Generalised T.B.	Human.
31.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Died.	70.	Generalised T.B.	Human.
32.	Murundi.	Congo native working in Kampala.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	70.	Generalised T.B.	Human.
33.	Muhima.	Living in kraal with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	43.	Generalised T.B.	Human.

Continued.

Continued.

No:-	TRIBE.	HISTORY.	CULTURAL CHARACTERISTICS.	ANIMAL INOCULATIONS.					TYPE.
				Animal.	Inoculum.	Killed or died.	Period of survi--val in days.	AUTOPSY.	
34.	Muhima.	Living in kraal with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	47.	Generalised T.B.	Human.
35.	Muhima.	Working as herdsman in Kampala.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	87.	Generalised T.B.	Human.
36.	Mutoro.	No history of cattle contact.	This strain grew poorly and was not improved on glycer--ine media. Dysgonic.	Rabbit.	10 mg., culture I.M.	Killed.	116.	Healthy. Small caseous abscess at site of inoculation.	
				Rabbit.	10 mg., culture I.M.	Killed.	129.	Healthy.	Dysgonic
				G.-pig.	Sputum, S.C.	Killed.	61.	Generalised T.B.	Human.
37.	Muganda, (Female).	No contact with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	277.	Regional lymph glands enlarged and caseous. Tubercles in spleen and lungs. Sub-lumbar and hepatic glands enlarged.	Human; low virulence
38.	Musoga.	No contact with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	68.	Generalised T.B.	Human.
39.	Munaruanda.	Cattle tribe; working in Kampala.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	66.	Generalised T.B.	Human.
40.	Munaruanda.	Cattle tribe; working in Kampala.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	44.	Advanced T.B.	Human.
41.	Muhima.	Working as herdsman near Kampala.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	65.	Advanced T.B.	Human.
42.	Muhima.	Living in kraal with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	62.	Advanced T.B.	Human.
43.	Mutoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Died.	53.	Generalised T.B.	Human.
44.	Mutoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	74.	Advanced T.B.	Human.
45.	Mutoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
46.	Mutoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
47.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	77.	Advanced T.B.	Human.
48.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	62.	Advanced T.B.	
				Rabbit.	0.01 mg., culture I.V.	Killed.	79.	Healthy.	Human.

Continued.

Continued.

No:-	TRIBE.	HISTORY.	CULTURAL CHARACTERISTICS.	ANIMAL INOCULATIONS.					TYPE.
				Animal.	Inoculum.	Killed or died.	Period of survi--val in days.	AUTOPSY.	
49.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
50.	Munyoro.	Child 3 years old; Father owns cattle.	Dysgonic growth not improved on glycerine medium.	Rabbit.	0.1 mg., culture I.V.	Died.	29.	Severe generalised miliary T.B.	
				Rabbit.	0.01 mg., culture I.V.	Died.	47.	Severe generalised miliary T.B.	Bovine.
51.	Muhima.	Living in kraal with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
52.	Munaruanda.	Cattle tribe;herding cattle.	Typical eugonic growth on glycerine medium.	G.-pig.	Sputum, S.C.	Killed.	56.	Advanced T.B.	Human.
53.	Muhima.	Living in kraal with cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	70.	Advanced T.B.	Human.
54.	Mugishu.	Living in same house with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
55.	Mugishu.	Lives in same house as cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
56.	Indian.	Owns cattle.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Died.	144.	T.B. of adjacent glands only.	Human.
57.	Munaruanda.	Working as herdsman.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Died.	143.	Advanced T.B.	
				Rabbit.	10 mg., culture I.M.	Killed.	91.	Local abscess only. Excellent condition.	Human.
58.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
59.	Munakikuyu.	Kenya native working in Kampala. Contact with cattle as a youth.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
60.	Muzinga.	Tanganyika native working in Kampala. Contact with cattle as a youth.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
61.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	Rabbit.	0.01 mg., culture I.V.	Killed.	94.	Healthy.	Human.
62.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	47.	Advanced T.B.	Human.
63.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.

Continued.

Continued.

No:-	TRIBE.	HISTORY.	CULTURAL CHARACTERISTICS.
64.	Muhima.	Herdsman.	Typical eugonic growth on glycerine media.
65.	Mugishu.	Lived in same house as cattle.	Typical eugonic growth on glycerine media.
66.	Mugishu.	Lived in same house as cattle.	Typical eugonic growth on glycerine media.
67.	Munaruanda.	Cattle tribe; working at Masaka.	Typical eugonic growth on glycerine media.
68.	Munaruanda.	Cattle tribe; working at Masaka.	Typical eugonic growth on glycerine media.
69.	Muganda.	No contact with cattle. Pulmonary and T.B. of glands, neck and groin.	Typical eugonic growth on glycerine media.
70.	Murundi.	Congo native working in Kampala.	Typical eugonic growth on glycerine media.
71.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.
72.	Mutoro.	No contact with cattle.	Typical eugonic growth on glycerine media.
73.	Mukiga, (Female).	No history of cattle contact.	Typical eugonic growth on glycerine media.
74.	Muganda, (Female).	Drinks a lot of milk and Father owns cattle.	Typical eugonic growth on glycerine media.
75.	Mugishu.	Lived in same house as cattle.	Growth at first poor, later typically eugonic.
76.	Mulango.	Works in Kampala. Herded cattle and drank milk as a youth.	Typical eugonic growth on glycerine media.
77.	Muhima.	Living in kraal with cattle.	Typical eugonic growth on glycerine media.
78.	Muhima.	Living in kraal with cattle.	Typical eugonic growth on glycerine media.
79.	Munaruanda.	Cattle tribe; working in Kampala.	Typical eugonic growth on glycerine media.

ANIMAL INOCULATIONS.					
Animal.	Inoculum.	Killed or died.	Period of survi--val in days.	AUTOPSY.	TYPE.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
G.-pig.	Sputum, S.C.	Killed.	32.	T.B. in adjacent glands, spleen and lungs.	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
Rabbit.	10 mg., culture I.M.	Killed.	97.	Local abscess only.	
Rabbit.	-do-	Killed.	108.	Healthy; local abscess only	Human.
-	-	-	-	-	Human.
Rabbit.	10 mg., culture I.M.	Killed.	108.	Healthy; local abscess only.	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.

Continued.

Continued.

No:-	TRIBE.	HISTORY.	CULTURAL CHARACTERISTICS.	ANIMAL INOCULATIONS.					TYPE.
				Animal.	Inoculum.	Killed or died.	Period of survi--val in days.	AUTOPSY.	
80.	Mutoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
81.	Mukiga.	No history of contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
82.	Muganda.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
83.	Mutoro.	Herding cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
84.	Arab.	Cattle dealer.	Typical eugonic growth on glycerine media.	Rabbit.	0.01 mg., culture I.V.	Killed.	122.	Healthy.	
				Rabbit.	10 mg., culture I.M.	Killed.	107.	Local abscess only.	Human.
85.	Mudama.	Lived in same house with cattle and drank milk.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
86.	Mulango, (Female).	Drank milk and Father owns cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
87.	Mugishu.	No cattle contact; drinks milk.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
88.	Mutoro.	Herds cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
89.	Mugishu.	No cattle contact; drinks milk.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
90.	Muganda.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
91.	Mwiru.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
92.	Munaruanda.	Works in Kampala. Cattle tribe.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
93.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
94.	Mwiru.	Agriculturalist. No contact with cattle.	Typical eugonic growth on glycerine media.	Rabbit.	10 mg., culture I.M.	Killed.	107.	Local abscess only.	Human.
95.	Muganda.	Pott's disease since childhood; Psoas abscess; drinks milk.	Typical eugonic growth on glycerine media.	G.-pig.	Pus, S.C.	Killed.	152.	Advanced T.B.	Human.

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Continued.

No:-	TRIBE.	HISTORY.	CULTURAL CHARACTERISTICS.	ANIMAL INOCULATIONS.					TYPE.
				Animal.	Inoculum.	Killed or died.	Period of survi--val in days.	AUTOPSY.	
96.	Muganda.	Father owns cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
97.	Mwiru.	Agriculturalist. No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
98.	Munaruanda.	Herded cattle and drank milk.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	83.	Advanced T.B.	Human.
99.	Mugishu.	Lived in same house as sheep and goats; drinks milk.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
100.	Munaruanda.	Cattle tribe; working in Kampala.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
101.	Muganda.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
102.	Munaruanda.	Herded cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
103.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
104.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
105.	Munyoro, (Female).	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
106.	Munaruanda.	Herded cattle and drank milk.	Typical eugonic growth on glycerine media.	Rabbit.	10 mg., culture I.M.	Killed.	107.	Healthy. Small retrogressive abscess only.	Human.
107.	Muganda.	Abscess in back; No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
108.	Mukiga.	Herded cattle and drinks milk.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
109.	Muzinga.	Tanganyika native. Pulmonary and T.B. neck glands. Worked with cattle and drinks milk.	Typical eugonic growth on glycerine media from sputum and pus.	Rabbit.	10 mg., culture I.M.	Killed.	107.	Healthy. Local abscess only.	Human.
110.	Munaruanda.	Cattle tribe; working in Kampala.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
111.	Mudama.	Herded cattle and drinks milk.	Typical eugonic growth on glycerine media.	G.-pig.	Sputum, S.C.	Killed.	106.	Advanced T.B.	Human.

Continued.

Continued.

No:-	TRIBE.	HISTORY.	CULTURAL CHARACTERISTICS.
112.	Mukiga.	Herds cattle.	Typical eugonic growth on glycerine media.
113.	Karamojan.	Early history cattle contact, later served in Police.	Typical eugonic growth on glycerine media.
114.	Lugwara.	Cattle-owning tribe; works in Kampala.	Typical eugonic growth on glycerine media.
115.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.
116.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.
117.	Munyoro.	Herds cattle.	Typical eugonic growth on glycerine media.
118.	Muganda.	No contact with cattle.	Typical eugonic growth on glycerine media.
119.	Arab.	Cattle dealer.	Typical eugonic growth on glycerine media.
120.	Muhima.	Herdsman in Kampala.	Typical eugonic growth on glycerine media.
121.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.
122.	Munaruanda.	Cattle tribe;working in Kampala.	Typical eugonic growth on glycerine media.
123.	Muganda.	No contact with cattle.	Typical eugonic growth on glycerine media.
124.	Muteso.	No contact with cattle.	Typical eugonic growth on glycerine media.
125.	Mumadi, (Female).	No contact with cattle.	Typical eugonic growth on glycerine media.
126.	Mukiga.	No contact with cattle.	Typical eugonic growth on glycerine.
127.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.
128.	Mugishu.	Lives in same house as cattle; drinks milk.	Typical eugonic growth on glycerine media.

ANIMAL INOCULATIONS.					
Animal.	Inoculum.	Killed or died.	Period of survi--val in days.	AUTOPSY.	TYPE.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
G.-pig.	Sputum, S.C.	Killed.	97.	Advanced T.B.	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.
-	-	-	-	-	Human.

Continued.

Continued.

No:-	TRIBE.	HISTORY.	CULTURAL CHARACTERISTICS.	ANIMAL INOCULATIONS.					TYPE.
				Animal.	Inoculum.	Killed or died.	Period of survi--val in days.	AUTOPSY.	
129.	Munaruanda.	Owns cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
130.	Mukiga.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
131.	Muganda.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
132.	Mukiga.	Fluid from T.B. knee. Owns and herds cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
133.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
134.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
135.	Munaruanda.	Lived in house with goats in Ankole.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
136.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
137.	Munyoro.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
138.	Mukiga.	No contact with cattle.	Dysgonic, not improved on glycerine medium.	Rabbit.	0.01 mg., culture I.V.	Died.	19.	Severe miliary T.B. of lungs.	Bovine.
139.	Mutoro.	Herds cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
140.	Mwiru.	No contact with cattle.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.
141.	Muhima.	Herding cattle near Entebbe.	Typical eugonic growth on glycerine media.	-	-	-	-	-	Human.

NOTES ON THE TRIBES FROM WHICH TUBERCLE BACILLI HAVE BEEN TYPED.

For the sake of clarity it should be explained that when referring to tribes the following prefixes are used in Luganda, which is the official language of the Protectorate :-

" Mu- " indicates the singular, referring to people, e.g., Muganda ;

" Ba- " indicates the plural, referring to people, e.g., Baganda.

Banaruanda :- 32 cases.

The majority of these cases were in itinerant labour. These people occupy the South-West corner of the Portectorate, in Kigezi district, and extend far into Ruanda-Urundi of the Belgian Congo.

They own large numbers of cattle of the intermediate type in which tuberculosis is not common. It is difficult to ascertain whether the Banaruanda become infected in their own country, or during their long trek of nearly 400 miles to the labour markets of Kampala. Several cases have recently been discovered in their own tribal area.

Banyoro :- 18 cases.

This tribe extends over a large area to the North and West of Uganda. They contain a fair mixture of Hamitic blood. The cattle are of the intermediate type and are few in number, although in the pre-European days the important chiefs owned large herds. One case was infect--ed with the bovine type of organism.

Bahima :- 18 cases; and Bairu :- 7 cases.

The Bahima are the Hamitic pastoral people of Ankole who immigrated from the Galla regions of Abyssinia. They own large herds of cattle in which the incidence of

(tuberculosis

tuberculosis is extremely high.

The Bairu are the indigenous agriculturalists of Ankole, and were originally serfs to the Bahima. In recent years, however, a considerable amount of inter-marry--ing has taken place, and the Bairu own large numbers of cattle closely imitating the Bahima in their methods of husbandry. Out of 6 cases of tuberculosis, two yielded bacilli of the bovine type. Is it possible that the Bairu, who have only recently acquired cattle, are more susceptible to the bovine organism than the Bahima, who have lived in the closest contact with their cattle for generations ?

Baganda :- 16 cases.

This tribe, which is one of the most advanced in Africa, inhabit the Buganda Province of Uganda. They are not in any sense a pastoral people although they own cattle. The herds are left in charge of the Bahima, who have complete control and live on the milk.

Batoro :- 10 cases.

These people are closely related to the Banyoro, and live in the Western areas of the Protectorate near the Ruwenzori mountains. Their cattle are of the intermediate type and blend into the Ankole breed in the South.

Bakiga :- 9 cases.

These people occupy the highland areas of Kigezi, and own large numbers of cattle of the intermediate type. One case yielded tubercle bacilli of the bovine type.

Bagishu :- 9 cases.

This tribe occupies the highland country of Mount Elgon. They own large numbers of cattle of the Zebu type, which are mostly housed at night in the huts of their owners.

Balundi :- 2 cases; Baziba :- 1 case; Bakikuyu :- 1 case; Bazinga :- 3 cases; Basubi :- 1 case.

These people represent tribes from the Belgian Congo, Tanganyika and Kenya, working in or near Kampala.

Arab :- 4 cases; and Indian :- 1 case.

These people are traders in Uganda.

Basoga :- 1 case; Balango :- 2 cases; Balugwara :- 1 case; Bateso :- 1 case; Bamadi :- 1 case; Bakaramoja :- 1 case; and Badama :- 2 cases.

These tribes occupy the Eastern and Northern Provinces of the Protectorate. Each tribe owns large numbers of Zebu cattle and, except for the Bakaramoja, are partly agricultural.

NOTES ON THE CASES IN WHICH BOVINE BACILLI HAVE BEEN ISOLATED.

(1). CASE No. 5.

Mwiru.

This patient, a man of about 25 years old, was in Mbarara Hospital suffering from advanced phthisis pulmonalis of long standing. He owned and lived in the kraal with his cattle, and drank large quantities of milk.

(2). CASE No. 10.

Mwiru.

This man, about 30 years old, was living in the kraal with his cattle in Ankole and drank milk. He had a cough of two years standing, but had not sought medical attention. No other history was obtainable.

(3). CASE No. 50.

Munyoro.

This was a male child, 3 years old, whose father owned cattle. The only clinical history was " cough for 1 year, chest indefinite " given me by the Medical Officer, Bunyoro, who kindly sent me the specimen of sputum.

(4). CASE No. 138.

Mukiga.

Male, about 20 years of age. The Medical Officer, Kigezi, has kindly forwarded me the following clinical report : " Extensive disease of left lung, and effusion into the right knee-joint. Hectic temperatures. " I was unable to demonstrate or isolate tubercle bacilli from the effusion, which was a clear, amber coloured fluid. There was no history of contact with cattle; this tribe, however, owns large numbers of cattle, and it is very probable that the history is unreliable. The cattle are of the intermediate type, and bovine tuberculosis is not common.

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UGANDA PROTECTORATE
POLITICAL

Statute Miles

MILES 0 20 40 60 80 MILES

Roads — | Railways ═══ | District Hqs ◎

Bdy Territorial + + + +
Provincial — · — · —
District — — —

29°-15' 30° 31° 32° 33° 34° 35° 35°-15'

4° 3° 2° 1° 0° 1°30'

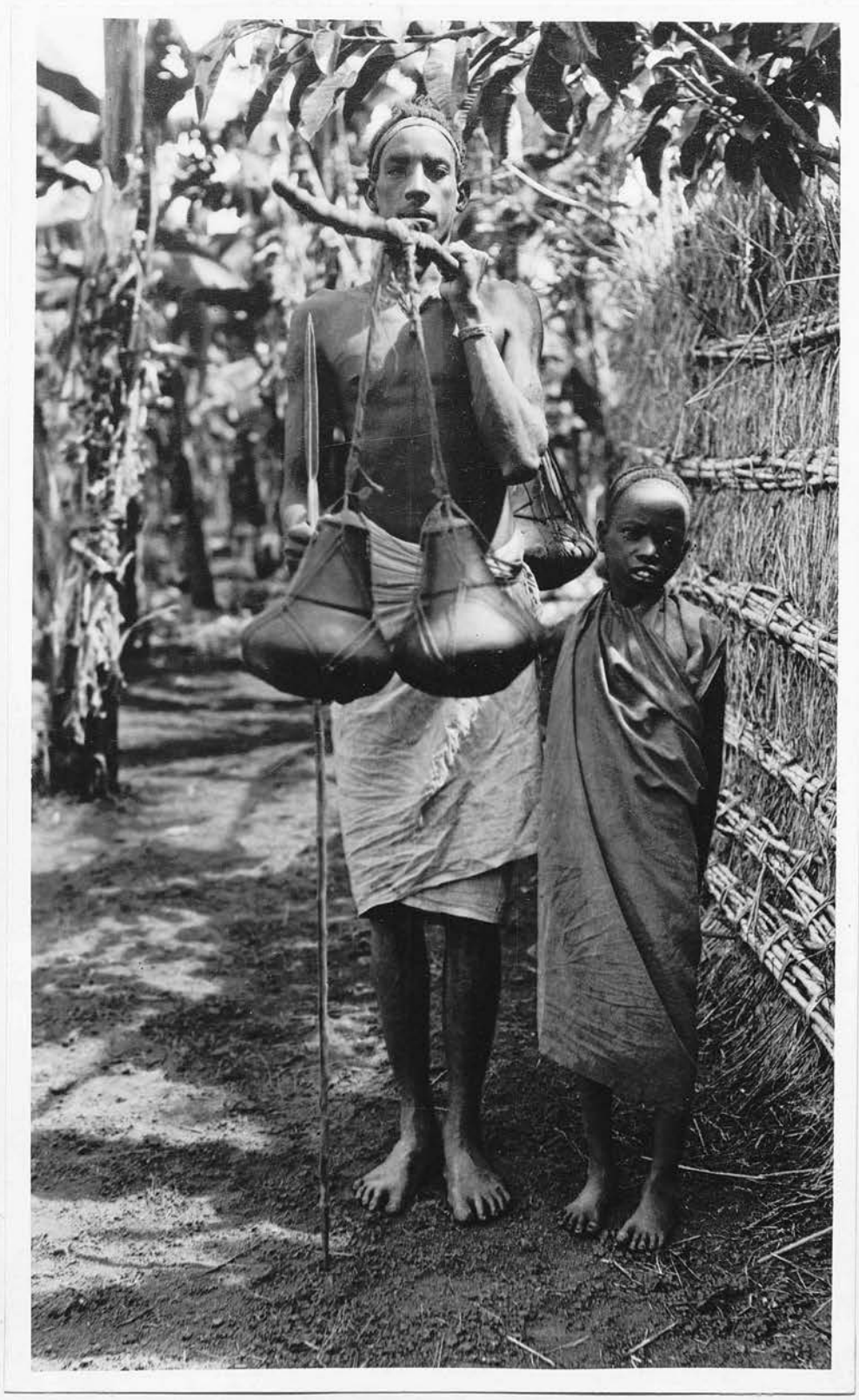
SUDAN
ABYSSINIA
BELGIAN CONGO
KENYA
UGANDA
TANGANYIKA
RUANDA URUNDI

Yei, To Juba, R. Kyo, R. Kaia, From Juba, Fr. Torit, Ikoto Post, Tereteima, Madi Opei, Nimule, Moyo, Umi, R. Koich, Palabek, Padibe, Kaabong, Koboko, R. Aswa, Kitgum, Romi, R. Pager, Albert Nile, Pabo, Aru, Arua, Vura, Rhino Camp, Site of Wadelai, War, R. Ora, Gulu, R. Aguga, Adilang, Paranga, To Lodwari, Moroto, R. Aswa, Pakwach, Minakulu, From Moto, Murchison Falls, Victoria Nile, Aboke, Lira, Aloi, Panyamur, Mahagi Port, Atura, Orungo, Amuria, Adachai, Aduku, Atuboi, Kachung, Tiriri, Kilo, MINES, Butiaba, Kikubi, Chiawante, Soroti, Kaberamaido, Masindi Port, Bisu, Kibero, Masindi, Kitoba, L. KWANIA, Kelle, Lale, L. SALISBURY, Muntu, L. KYOGA, Bugondo, Kaiso, Hoima, R. Kafu, Nakatoma, Serere, Ngora, Kuma, Irumu, Kasenyi, Kidera, Munteme, Nakasongola, Buyende, Pallisa, Siroko, Mbale, ELGON 14,178, Bubulu, Kitale, R. Nkusi, Nalweyo, Namasagali, Kamuli, Vukula, Budaka, Mboga, Ndaula, Kagade, Nkoko, Kibogo, Wakyato, Luwero, Kaliro, NSINZE, Malukisi, R. Semliki, Kitoma, R. Muzizi, Kakumiro, Mbulamuti, Busembatia, Rusekere, Butiti, Kyanyojo, Bukomero, Bukalasa, Luzinga, Tororo, Fort Portal, Mubende, Bombo, Kasawo, Namaliga, Iganga, Busia, Beni, Kyegegwa, Gayaza, Bugembe, Sikiro, Bugiri, Jinja, Mityana, KAMPALA, Kiterera, RUWENZORI, L. WAMALA, Mpigi, Mukono, Luggazi, Port Bell, Mjanji, Mumias, Kakamega, Misebere, Kilembe, R. Mpanga, R. Katonga, Makole, Kibanga, Buvuma I., Kabulasoke, ENTEBBE, R. Nzoya, Kasindi, Katwe, L. GEORGE, Sembabule, Katebo, Kome I., R. Yala, Kisumu, Ibanda, Kutungurú, Seses Is., L. EDWARD 3000, Lyantonde, Masaka, Bukakata, Bushenyi, Mbarara, Rukai, R. Ishasha, Rukungiri, Gayaza, Ntungamo, Mwirasandu, Nsongezi, Katera, R. Rutshuru, Kumba, Lubale, Mitai Aiyu, R. Kagera, Nyakanyasi, Shirati, Rutshuru, Kabale, Kyaka, Bukoba, MUFUMBIRO, LAKE VICTORIA 37°20'

Uganda Survey Dept 1935

●..... AREAS FROM WHERE HUMAN TUBERCULOUS MATERIAL HAS BEEN COLLECTED.

Fig. XVI



A MUHIMA (ANKOLE) CARRYING MILK POTS OR " BYANZI " .

Fig. XVII

HERDSMENS' HUTS IN A BAHIMA'S (ANKOLE)

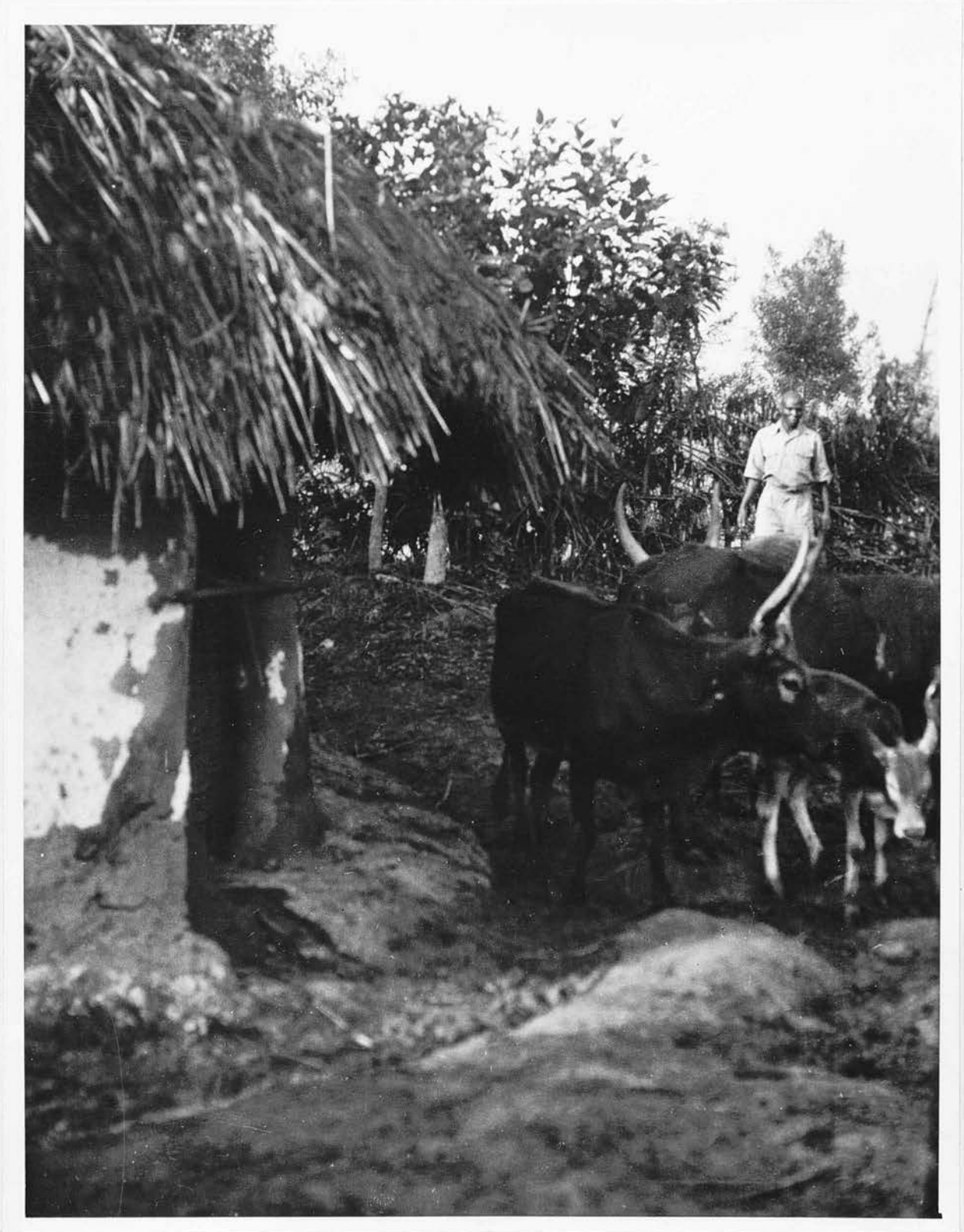
CATTLE KRAAL .

Fig. XVIII.

A CLOSE VIEW OF A HERDSMAN'S HUT IN A

MUHIMA'S CATTLE KRAAL. (ANKOLE).

Fig. XIX.



CATTLE KRAAL AND NATIVE HUT IN KIGEZI.

PART VII

MISCELLANEOUS INVESTIGATIONS

(A). SPONTANEOUS TUBERCULOSIS IN A RABBIT.

Griffith (1930) states that the domesticated varieties of rabbits are remarkably free from tuberculosis in the absence of obvious sources of infection.

The subject of the present case was a Chinchilla rabbit which was procured from Nairobi, Kenya Colony, and used for breeding purposes.

After four months it was found dead in an open run. Autopsy revealed, in the thoracic cavity, a mass of large firm and fibrous yellow tubercles up to the size of a hazel nut. The tubercles filled the mediastinal space and were attached to the pleural surface of the diaphragm and the parietal pleura of both sides of the thorax. The picture was one of advanced " perlsucht " lesions as seen in cattle. The lungs themselves were displaced upwards and forwards. The right lung showed six small tubercles, and the left lung two.

There was one raised tubercle at the posterior pole of the left kidney. The hepatic lymph gland was hard and on section was caseo-fibrinous. There were no lesions in the spleen or liver.

Acid-fast organisms were numerous in films from the thoracic tubercles. The source of infection could not be traced in Uganda. Some 28 rabbits in the breeding pens were all killed immediately and autopsies carried out. In no case was there any trace of tuberculosis.

Cultures were prepared directly from the tubercles in the thorax, and a dysgonic growth obtained. On glycerinated media the growth was not improved.

A guinea-pig inoculated subcutaneously with the tuberculous material was killed after 80 days and showed advanced generalised tuberculosis.

A rabbit received 0.01 mg., of a 21-day old culture intravenously, and died of severe generalised miliary tuberculosis after 26 days.

The organism is a bovine type of standard virulence.

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(B). SPONTANEOUS TUBERCULOSIS IN A WHITE RAT.

This rat was one of 37 received from the Human Trypanosomiasis Institute, Entebbe. Their diet had consist--ed of unboiled milk and bread, together with oats and bran. The day after their arrival at this Laboratory one was found dead.

Post-mortem examination revealed the whole thorax filled with large firm tubercles about 0.5 cm., in diameter, which had entirely replaced the lung tissue except for a small portion of the apices. The tubercles were surrounded by a strong fibrous capsule, and on section consisted of a solid mass of firm caseous material, free from fibrous tissue or calcareous matter.

Films prepared from the caseous substance showed large numbers of acid-fast organisms.

The spleen was enlarged and free from tubercles, and films did not show any acid-fast bacilli.

Bacteriological Examination :-

Cultures were prepared directly from the tubercles in the usual way, and a dysgonic growth was obtain--ed which was not improved on glycerinated media.

Animal Inoculations :-

(1). Guinea-pig inoculated subcutaneously with caseous material was killed after 45 days. Autopsy revealed enlarged and caseous regional lymphatic glands, i.e., the superficial inguinal and sub-lumbar. The spleen was enlarged and contained two tubercles about the size of lentil seeds. There were a few scattered tubercles in the lungs.

(2). Guinea-pig inoculated with caseous material as above and killed 54 days later, showed enlarged and caseous regional lymphatic glands. The spleen was enlarged but contained no tubercles, whilst the lungs showed a number of scattered tubercles.

(3). Rabbit inoculated intravenously with 0.01 mg., of a 21-day old culture died after 33 days. Autopsy showed severe miliary tuberculosis of both lungs and spleen.

Conclusions :-

From the cultural characteristics and animal inoculations it is evident that the strain is a bovine one of standard virulence for rabbits.

Discussion :-

This case is of considerable interest in view of Griffith's (1930) remarks on the subject of tuberculosis in the white rat, in which he states : "The white rat is highly resistant to tubercle bacilli introduced by feeding and subcutaneous inoculation. The bacilli multiply in the tissues without, however, producing any cellular reactions visible microscopically. The rat tolerates the toxins of the tubercle bacillus, and death is the result of the multiplica--tion of the bacilli in the cells of the vital organs."

In this case it seems as if the rat became infected from the milk, as several cases of tuberculosis

(have

have occurred at the Human Trypanosomiasis Institute , Entebbe, in other animals fed on raw milk.

The presence of gross macroscopical tubercu--lous lesions is difficult to account for, and this appears to be a rare case in which the usual " Yersin " type of infection has not occurred.

The remaining 36 rats were killed and examined but no tuberculous lesions were evident to the naked eye.

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up to February 1936.

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