A SECOND OUTBREAK OF ANTHRAX AMONGST GAME ANIMALS IN THE KRUGER NATIONAL PARK.

5th June to 11th October, 1960.

By U. de V. PIENAAR, Ph.D.

(Assistant Biologist, Skukuza, Kruger National Park)

1. ONSET, MAGNITUDE AND COURSE OF THE EPIZOÖTIC.

During a visit by the Chief Nature Conservation Officer to the Punda Milia section on the 5th of June, it became apparent that anthrax had once again set foot in the northern district of the Kruger National Park. The first case, that of a kudu cow, was discovered along the Hlamalala road to Pafuri approximately 3 miles south of Klopperfontein.

Confirmation of the diagnosis was obtained from Onderstepoort within a few days and immediately steps were taken in an attempt to curb the outbreak.

This campaign was initially launched from Punda Milia, but had to be moved south in due course to Shingwedzi and Shangoni sections, and finally to Letaba and Mahlangene before the epizoötic had subsided.

After a cursory survey of the original infected area, it soon came to light that the disease had already obtained a firm foothold and had assumed epidemic proportions in the vicinity of Klopperfontein, the headwaters of the Shisha and around Dzundwene hill.

In view of this substantial advantage (more than 2 months according to indications) the disease resisted all initial suppressive measures, and the infection spread rapidly and with appalling consequence westwards towards Punda Milia, as well as eastwards towards Machai and Malonga on the eastern boundary. In spite of intensified control measures during July, the disease also moved southwards with exasperating finality across the Mapongole, Pukwane and Bububе rivers until it reached last year's infected area along the Shingwedzi (vide Pienaar (1960)). Although mortality here was reasonably severe, there was at no stage signs of epidemic proportions. Cases were more of a sporadic nature throughout the old infected area, until the last carcase was found in the vicinity of Shingwedzi poort on October 2nd.

In the Dzombo block to the south and east of the Shingwedzi restcamp fatalities occured amongst particularly kudu, waterbuck and roan antelope from August 25th onwards, but again the occurence was of a more enzoötic nature.

In the relatively sparsely-populated zone south west of the Shingwedzi river mortality was confined to a few isolated cases near Timatoro windmill, Mahlambandlovu pan and along the Mbyashishe river.

On August 22nd the disease was first noticed amongst game in the Makadze area near the eastern boundary of Letaba section, but closer investigation proved this to be a new outbreak and devoid of any connection with the northern infected areas from which the disease was gradually moving south. A strip twenty miles broad and free of infection separated these two areas, although the possibility of a point of contact within the Portuguese territory to the east was suggested by an aerial survey at a later stage.

A few sporadic cases were found during the early part of September south of the Letaba river, along the Mahudzi spruit and near the rest camp, and it was feared that the disease would spread even further southwards, where it would threaten the great herds of game in the central district beyond the Olifants river. Fortunately, however, the movement southward was ultimately arrested here. Instead of southward the infected area was extended towards the west and the first case along the Tende river was discovered on September 17th. It was along the course of this river that the disease made its final onslaught, and on October 11th the last case of the present epidemic was reported from here.

In a few instances it was found that areas which produced no fatal cases for a considerable time suffered a re-infection e.g. in the vicinity of Punda Milia camp, Malonga and Pafuri, however, the second paroxism was in most instances less severe than the first.

The immediate origin of the present epidemic is unknown. However, there are strong suggestions of some connection with last year's outbreak in the Shingwedzi and Shangoni sections, and an insidious penetration of Punda Milia section from here, during the late summer and autumn. The actual trigger-mechanism which set off the epizoötic condition is likewise an unknown factor but may have a climatological link.

It must be stressed here that during the period under discussion, other areas were also hit by anthrax epidemics. From May-July of this year there was a fairly extensive outbreak amongst game in the south-western part of the Caprivi strip (in the Tsetse fly belt along the Linyanti river), during which time 27 kudu, 7 roan, 3 buffalo, 2 reedbuck, 2 warthog, 1 eland, 1 sable, 2 elephant and a lion succumbed to the disease. From the Bechuanaland side of the Linyanti reports were received of deaths amongst giraffe, leopards and hyenas.

On September 23rd some cattle died of anthrax on a farm to the south of the Crocodile river, near Malelane, and in the Native Reserve near the Swaziland border. On October 1st there was another case amongst cattle near Mtimba to the west of the Nsikazi river and on October 11th notice was

served that 47 farms south of the Crocodile river had been placed under anthrax quarantine.

Reports were also received from Portuguese East Africa during October that anthrax was rife amongst buffalo herds at Mpusi, east of Mapai.

The indications in all cases are that although the outbreaks cannot be directly linked with the amount of moisture in the soil (some of the areas being marshy and others semi-desert), they were all associated with marsh-land, pans, pools in rivers or other natural waters drying up and with large numbers of animals concentrating at the limited available watering places during the dry season.

The general impression confirms the theory concerning the cyclical nature of anthrax epidemics and the important rôle of climatic factors as trigger-mechanism. These aspects, however, require considerable additional research.

2. EPIZOÖTOLOGY AND PATHOGENICITY.

As was the case in last year's outbreak and the Caprivi epidemic, kudu again suffered most severely of all affected species. These animals are apparently extremely susceptible and the mortality was generally very high. Other animals such as zebra and buffalo which also occur in substantial numbers in the infected areas and which were likewise subjected to the disease, were relatively lightly affected — a phenomenon that can only be interpreted in terms of their inherent resistence against the disease.

Serological analysis of the blood of these animals will in all probability indicate significant differences in the globulin fraction.

The waterbuck population was again dealt a severe blow and the meagre ranks of the roan antelope were thinned out in a most disquieting manner.

It will be apparent from the undermentioned list of carcasses that a number of animal species died during the present epidemic which were not affected by the disease last year, amongst others, zebra, nyala, reedbuck, bushbuck, steenbuck, duiker, giraffe, elephant etc., as well as a ratel, genets, leopards and two lionesses which fed on infected carcasses.

Another interesting manifestation of the present outbreak was the fact that for the first time impala were found dying of the disease. With one exception, however, all the dead impala were found in the Pafuri area, where the animals during that time were subjected to an acute food shortage due to severe overgrazing, and in many instances had already showed signs of deficiency diseases. Under normal conditions it would appear, therefore, that impala in healthy physical state are practically immune to the local strain of anthrax bacteria.

An analysis of the carcase-data indicates that, but for the cases of kudu and steenbuck, the large majority of fatalities were again, like the previous

year, amongst male animals. It was noteworthy that in such cases where a species was particularly susceptible, adult animals in their prime constituted the majority of carcasses, although undernourished as well as young individuals were no exception. Very few yearling calves or lambs were found, and it appears that even in the case of kudu, calves of less than a year old present much greater resistence against the disease than adult animals.

ANTHRAX CARCASSES FOUND IN THE NORTHERN DISTRICT OF THE KRUGER NATIONAL PARK FROM JUNE 5th — OCTOBER 11th 1960.

Species	Female	Male	Sex not known	Total
Kudu	236	533	2	771
Nyala	20	8	—	28
Bushbuck	7	6	—	13
Waterbuck	48	27	—	75
Reedbuck	2	3	—	5
Roan	18	20	3	41
Impala	2	5	—	7
Buffalo	41	12	5	58
Zebra (Burchell's)	8	5	3	16
Giraffe	1	—	1 ?	2
Steenbuck	3	7	—	10
Grysbuck	1	—	1	2
Duiker	1	1	—	2
Elephant	2	1	—	3
Warthog	3	—	2	5
Bushpig	—	—	1 ?	1
Baboon	—	—	1 ?	1
Lion	—	2	—	2
Leopard	2	2	—	4
Cheetah	—	—	1	1
Ratel	—	—	2	2
Genet	1	—	4	5
TOTAL				1,054

Of the larger cloven-hoofed species, only eland, sable, tsessebe and blue wildebeest escaped the scourge entirely. Of the carnivora, hyaena, jackal and wild dog were unaffected. No hippo died during the present epidemic, but they are nevertheless susceptible as was proved by last year's case at Mahlangene, as well as by the confirmation of Bere (1959) from the Queen Elizabeth National Park, Uganda :

"Anthrax is known to affect hippo and to occur sporadically in the area, although the rate of mortality is not high."

No dead vultures or other birds of prey were found. Of the smaller mammals and rodents apparently none contracted the disease although carcasses of the last mentioned may have been overlooked by the labour-gangs.

A donkey died near Punda Milia gate after having watered at an infected pool within the Park boundaries.

Portuguese natives at Pafuri handled and partook of the meat of a dead kudu and of their number two subsequently died of the disease.

The carcase of one baboon was also found but a positive diagnosis could not be made as putrefaction had already set in.

In addition to the above list, the following carcasses were found during clearing-up operations, but in view of the fact that these constituted merely old bones and withered pieces of skin, it is impossible to ascribe their death definitely to anthrax or alternatively to carnivora or other causes: 45 kudu, 3 waterbuck, 6 nyala, 6 buffalo, 1 sable, 2 tsessebe, 3 impala, 1 zebra, 1 warthog and 2 bushbuck.

SYMPTOMS

No post-mortem examinations were conducted on any of the carcasses, and diagnoses were made entirely from microscopic examination of blood smears. Externally, however, the symptoms in practically all the fresh cases were alike:

There were haemorrhages from the nostrils and other natural openings and in the case of buffalo often blood-stained faeces. The blood was dark-red in colour and the clotting-time greatly prolonged. Droplets of blood-stained serum oozed through the skin especially on the ears (most evident in the case of kudu), the neck, the forelegs and in the groin. The carcasses soon became bloated and putrefaction set in rapidly. There was no evidence of subcutaneous or perineal swelling or oedema in the zebra carcasses that were found. In the majority of cases it appeared that death occured suddenly and there were few or no signs of kicking or struggling. A zebra was found dead with a mouthful of green grass on which it was feeding. In other cases death set in more gradually and these cases could not be referred to the peracute form of the disease.

In one case a kudu bull dropped in its tracks but another 30 minutes passed before the animal was dead. It lay in the same spot, kicking spasmodically. Breathing was laboured and uneven and there was a frothy haemorrhage from the nostrils. The eyes were protruding and fearful. In another case a buffalo bull struggled and bellowed for hours during the night in the river-bed below Shingwedzi camp before it died.

A lioness was found 'in extremis' near the Makadze windmill and had to be destroyed. It was too weak to move and the trachea was all but closed by a massive swelling around the throat. Putrefaction of the tongue and pharynx had already set in and the infection probably entered through a wound in the mouth or throat.

According to data available the incubation period under natural conditions varies a great deal, and depending on the inherent resistance of the animal and the degree of infection an animal may apparently die as soon as 48 hours after contracting the disease or walk about for as long as 14 days (or even longer) before succumbing.

DISSEMINATION AND SOURCES OF INFECTION

As was the case in the previous epidemic, the infection was apparently disseminated chiefly by vultures from dead animals on which they fed to watering places which they visited in order to bathe or drink. In this manner a large number of natural waterholes as well as drinking holes situated at windmills and artificial dams were contaminated with the deadly bacteria or their spores.

Herd-animals like buffalo and then also elephant, warthog, and other animals that are fond of wallowing in mud, could presumably carry infected mud from one waterhole to the next and were probably instrumental in the infection of the Hape pan at Pafuri. This waterhole had been pickeled from an early stage by Native Rangers in order to prevent vultures from bathing there.

The excreta of vultures and all carrion-eaters that have fed on anthrax carcasses is another important means of contamination of water and grazing with anthrax spores which have passed untouched through their digestive tracts. Even the dung of non-susceptible animals which have fed on infected grazing or drank from heavily infected pools may cause the pollution of uninfected grazing or water.

A number of animals died in or around certain waterholes, the carcasses were opened by crocodiles, terrapins etc., and in this manner the water was infected.

Osteophagia does occur amongst game animals, especially during the winter months or in overgrazed areas, however, this cannot be regarded as a factor of importance in the dissemination of the present epizoötic. Similarly blood-sucking insects such as *Tabanus, Hippobosca* and *Stomoxys* spp. as well as other factors such as tick birds, which can transmit the disease through direct innoculation, may for the most part be left out of consideration.

In certain instances, however, mortality in the present epidemic could not be related to infected drinking water, and here the Pafuri area serves as

an excellent example. After extensive patrols on foot and subsequently from the air, all possible infected waterholes were tracked down and made completely inaccessible to game by the 6th of August. In spite of these measures, animals were still dying here up till September 5th and other sources of infection had to be sought. It was subsequently revealed that carcasses lying about undiscovered in the veld for a few days were covered with blowflies. These insects scattered at any sign of disturbance and perched in their thousands on the leaves of shrubs and trees in the vicinity. In this manner the leaves of a great many trees and shrubs were probably polluted with their excreta or carrion particles adhering to their feet. It is significant that the highest mortality rate at Pafuri occurred amongst kudu and nyala — animals which are almost entirely browsers, and had of necessity to feed on the leaves and twigs of shrubs and trees during that time, because of the overgrazed state of the habitat.

Noteworthy also was the fact that the mortality dropped considerably after a number of very severe windstorms which divested the vegetation at Pafuri of a large number of leaves.

Flies and blowflies must therefore be regarded with vultures as important disseminators of the disease (vide Sen & Minett, 1944).

The bloated but untouched carcase of a buffalo bull, several days old, was found. Smears were made of the blood as well as the thick, tarry fluid in which the masses of maggots in the mouth cavity and eye-sockets were working. The blood-smear showed no anthrax bacteria on examination, although numerous putrefaction bacteria of diverse types were present. Interesting, however, was the finding of countless numbers of anthrax bacteria in the 'maggot matrix' — these being actively dividing vegetative forms.

The most important source of infection was undoubtedly the drinking water however, and was probably caused either by spores lying latent in the bottom sludge and brought to the surface by the churning hooves of animals entering the receding waters, or alternatively by polluted vultures (or other carrion-feeders) having bathed in such water in their hundreds.

Water and sludge samples of a large number of dams and waterholes were taken and although the presence of *Clostridium septicum* in practically all cases considerably hampered the isolation of anthrax spores, the research workers at Onderstepoort obtained positive results through the innoculation of guinea pigs.

SUPPRESSIVE MEASURES AND HYGIENE CAMPAIGN

Suppressive measures applied were aimed chiefly at (a) the incineration of all carcasses of animals which died of anthrax, and (b) the elimination of all potential sources of infection and the provision of clean water.

During the early stages of the campaign which was impeded to a certain extent through lack of manpower and transport, the burning of carcasses

was a very tedious procedure as an area around each carcase had to be cleared of grass first in order to minimize the danger of accidental veld-fires. On the 16th of June, however, a substantial shower of rain was received, and it was decided to burn out the blocks in which the mortality was most severe, despite the dangers purported by a dry winter. This program was successfully concluded within the next two weeks with little damage to the vegetation.

The area eventually burnt out encompassed all veld beyond (north of) the Pongolo river in the west and the Babalala-Shingomene firebreak in the east except the botanical reserve north of Punda Milia, the Nwambiya block and the block between the Klopperfontein-Malonga firebreak and the main road to Pafuri.

The burns had the desired effect everywhere in that there was sufficient unburnt grazing (especially in the vleis) for the animals to feed on, and after the new growth had come up, it prevented to some extent the straying of sick animals into uninfected zones. The greatest advantage gained however, was that the burnt veld facilitated the rapid tracking down and burning of carcasses, and the labour gangs which by this time had grown in number and were properly organised, were now in a position to make up the leeway gradually.

Carcasses of all animals up to the size of buffalo were incinerated on pyres of dry wood. The elephant carcasses were either buried by means of a bull-dozer or enclosed by a coral of thornbush, allowed to rot away and the remains were then incinerated.

It soon became evident however, that despite all attempts to destroy carcasses the epidemic continued without abatement and as fiercely as ever. An ever increasing number of new areas were infected in view of the fact that it was often extremely difficult to localise a source of infection and there was no effective means of destroying or disinfecting such polluted water.

It was generally admitted that the disinfection of contaminated water or mud was practically impossible except by means of poisonous or corrosive substances such as mercuric chloride, phenol or formalin, which would naturally render such water dangerous to game.

The pumping out or draining of infected waterholes was soon abandoned in view of the danger of further dissemination of the anthrax spores. The only practical expedient adopted then was to close such infected waters by means of hedges of thornbush so that animals were denied all access to the water. This presented however, no solution to the problem as the ability of anthrax spores and vegetative forms to maintain themselves in a medium (water and mud), where they are subjected to competition (and possibly predation) from the natural microfauna, was an unknown factor. Such a waterhole might then theoretically have to be isolated for many years and made permanently inaccessible to game. In this manner practically all artificial watering points in the north and many natural ones would have had to be destroyed.

Acting on the advice of Dr. Schwärer of the Medical Research Institute it was decided, in spite of wide-spread scepticism, to experiment with a disinfectant "Tetramine" (di-decyl, dimethyl ammoniumbromide), which is a non-poisonous substance but with powerful antiseptic properties, on an isolated drinking-hole (i.e. Malonga, near the eastern boundary of Punda Milia section). The disinfectant was applied in a concentration of 1 part in 1000 parts of water.

Although a number of animals had died in this area, the mortality stopped abruptly soon after the addition of Tetramine to the water.

On the strength of these encouraging results, a large quantity of the disinfectant was acquired (unfortunately it is very expensive and can not be utilised on an extensive scale) and applied with particular success to a number of infected natural waterholes and windmill dams.

At a later stage a related substance, 'Hyamine 2389' (alkyl tolyl trimethyl ammoninum chloride), was utilised successfully. The latter was still effective when diluted down to 1 part in 10,000 parts of water.

The intrinsic value of both these quaternary ammonium compounds in the destruction of anthrax bacteria was subsequently demonstrated experimentally at Ondersiepoort. In both cases the vegetative forms are destroyed rapidly and completely, and even the spores after 48 hours exposure are affected detrimentally in that their fatal action on injected guinea pigs is considerably retarded and even cancelled in some cases.

The application of chemical substances was, however, not acceded to without considerable misgiving and caution in view of their possible effect on game drinking water treated in this manner for a long period. There is a distinct possibility that both these substances would have a deleterious effect on the rumenflora of ruminants and these animals might thus develop ketosis or other metabolic disturbances.

For this reason only waterholes that were rapidly drying up and others where there was a reasonable influx of clean water (e.g. springs and windmill dams) were treated with these substances. Elsewhere, especially in rivers and spruits, the infected waterholes were as a rule merely closed up with thornbush to await the cleansing action of the heavy summerfloods.

As a result of the intensive search and destruction of carcasses and the treatment of infected waterholes, a substantial area (which included the original infected area) was systematically cleaned up and the mortality rate dropped gradually. Unfortunately large tracts of country remained infected due to their inaccessibility — an obstacle which hampered the hygiene operations considerably and allowed the disease to be disseminated still further. Thus the whole of the broken country to the north of the Punda Milia-Pafuri road was ultimately infected.

At this stage a light plane was used to track down and localise all existing natural water points, and it was necessary to construct a number of new roads e.g. along the Madziringwe, Mapongola, and Pukwane rivers, with a heavy bulldozer in order to penetrate these inaccessible areas with the labour gangs.

A large number of temporary picket posts were established throughout the infected area in order to facilitate proper supervision and immediate action (vide map). The exceptional importance of constant vigilance and mobility was stressed more than ever at this stage.

In many instances it was now possible to track down carcasses prior to their dismembering by vultures and carrion feeders and the resultant dissemination of the infection.

A number of waterholes and pans were picketed by native rangers to prevent vultures from bathing there.

The breeding places of vultures in border areas were destroyed in order to eliminate the danger of local infection.

The hygiene campaign was continued incessantly even after the first signs of abatement of the epidemic and the whole infected area was systematically combed and rid of all old carcasses. The excreta of vultures at their roosts and around certain pans where they bathed in their hundreds, was burnt with gas-burners before the onset of the raining season. Dry mudholes and smaller pans which could not be treated with Tetramine or Hyamine were covered up and leveled by means of a bull dozer.

All windmill dams in the infected area were provided with concrete floors, replacing the existing mud floors, and at all windmills which delivered into mudholes a suitable type of concrete dam, which could be easily disinfected, was constructed. The latter has no overflow into a mudhole and is provided with a ball-valve mechanism and by-pass so that water is pumped back into the bore-hole when the dam is filled to capacity. The surplus water does not come into contact with the water in the dam, so there is no possibility of the bore-hole itself becoming infected.

It was finally decided to burn out the whole of the infected area in stages, and at a later juncture, in order to destroy all possible contaminated grazing, dung etc.

PREVENTIVE MEASURES

The suppressive methods described above may also be considered as prophylactic measures regarding future epidemics but not as permanent security, owing to the infeasibility of eliminating all potential sources of infection.

The only effective and safe prophylactic measure is the building up of an immune stock of game in these areas. Despite the fact that a number of

animals in the northern district must have contracted the disease in a mild degree and thus built up an acquired immunity, and the inherent immunity of others are such that they are able to withstand the onslaughts of the anthrax bacterial toxins, their offspring might in many cases be susceptible.

It is impracticable of course to inject game animals with the existing anthrax vaccine in the normal way. The administration of a 'per os' vaccine through the drinking water is a distinct possibility however, and Onderstepoort is at present conducting research on these lines. Another aspect receiving expert attention is the life-expectancy of virulent and attenuated anthrax spores in water and mud under natural conditions.

If these efforts fail, the only safeguard against a repetition of this disasterous period in the history of the Kruger National Park would depend on the absolute and incessant vigilance of the nature-conservation staff.

The fencing of the Park boundaries will ensure that animals do not stray out and contract the infection beyond our sphere of influence. It is anticipated that the fencing of the western boundary and the Pafuri corner will be completed by the end of 1961.

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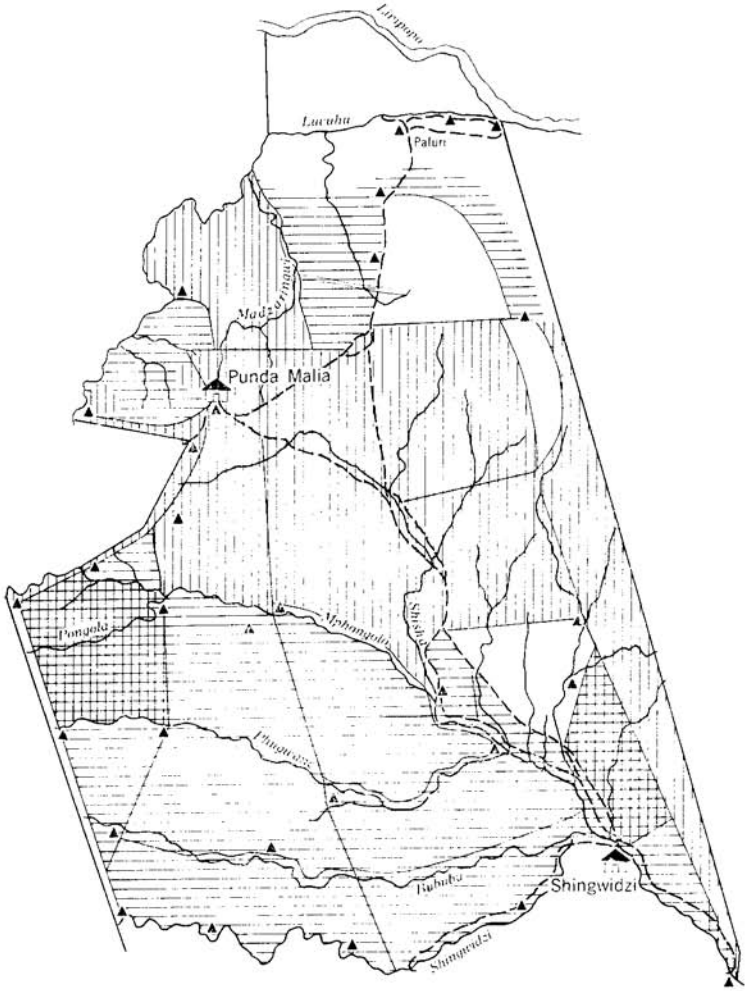
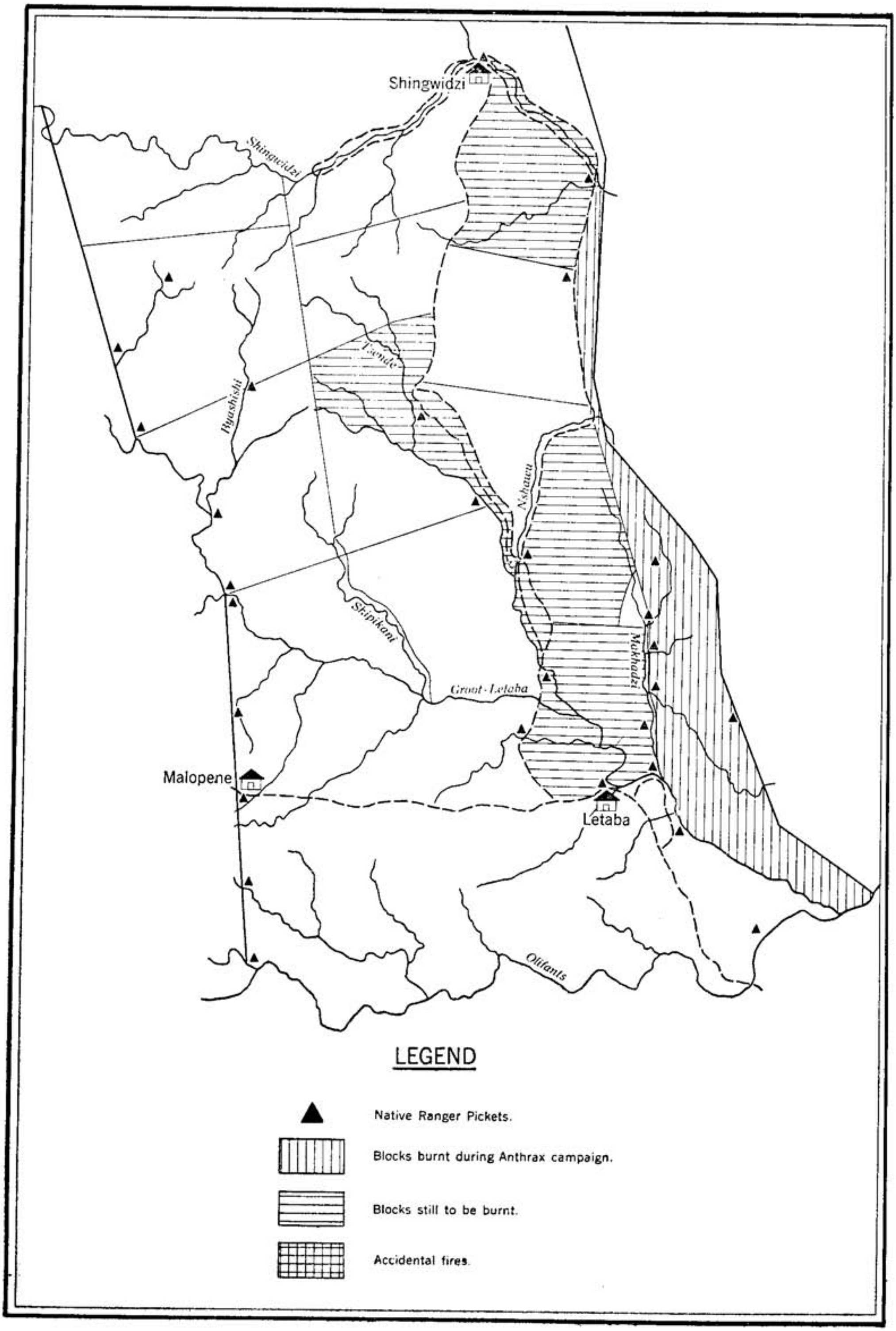
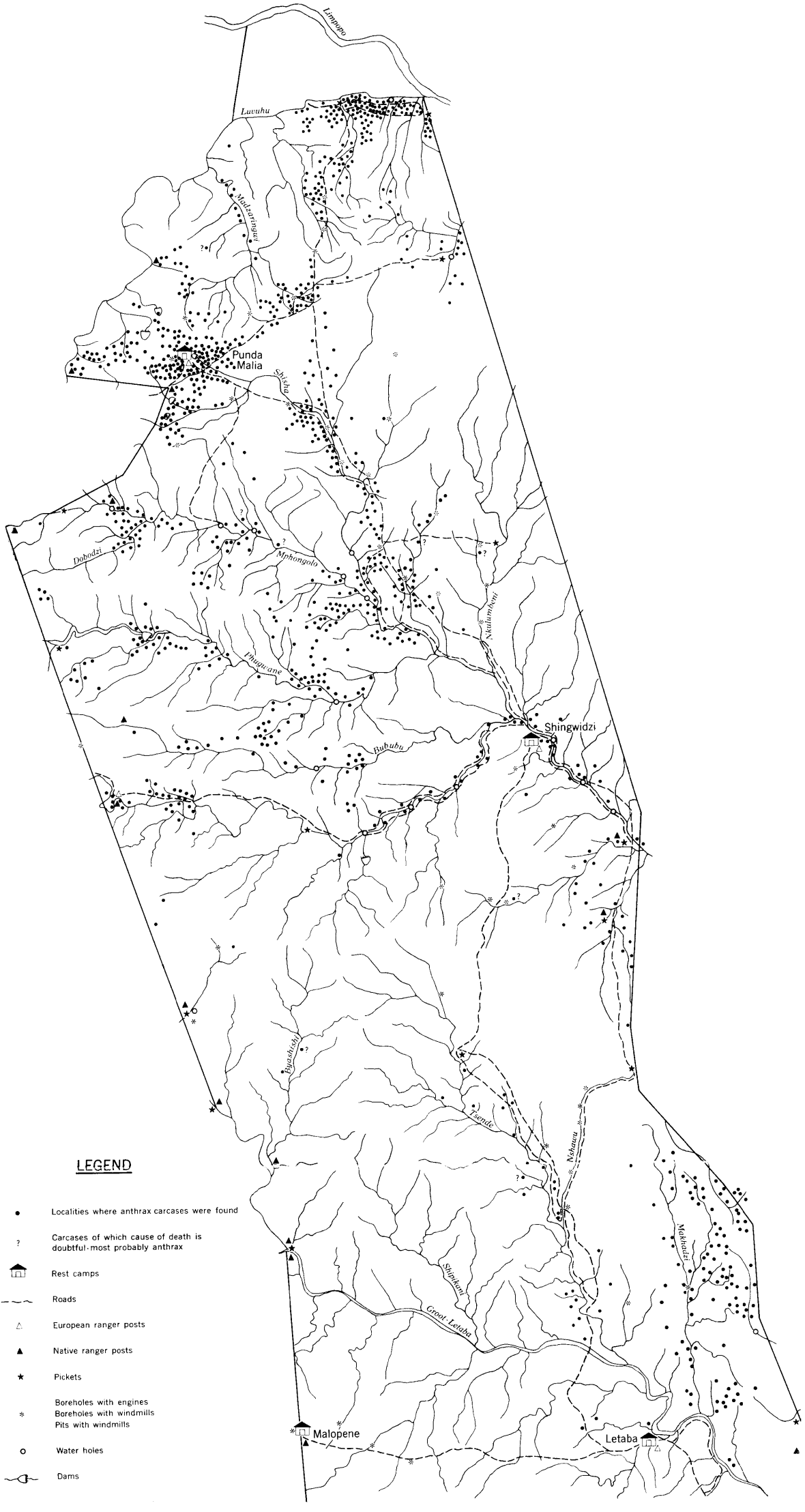


LEGEND

- Native Ranger Pickets
- Blocks burnt during Anthrax campaign
- Blocks still to be burnt
- Accidental fires



Shingwidzi
Shingwidzi
Tsende
Byashishi
Nshawu
Shipikani
Groot-Letaba
Mukhadzi
Malopene
Letaba
Olifants
LEGEND
Native Ranger Pickets.
Blocks burnt during Anthrax campaign.
Blocks still to be burnt.
Accidental fires.


Limpopo
Luvuhu
Madzaringwe
Punda Maria
Shisha
Dobodzi
Mphongolo
Nkulumbeni
Phugwane
Shingwidzi
Bububu
Byashishi
Tsende
Nshaau
Makhadzi
Shipikani
Groot Letaba
Malopene
Letaba
LEGEND
Localities where anthrax carcases were found
Carcases of which cause of death is doubtful - most probably anthrax
Rest camps
Roads
European ranger posts
Native ranger posts
Pickets
Boreholes with engines
Boreholes with windmills
Pits with windmills
Water holes
Dams