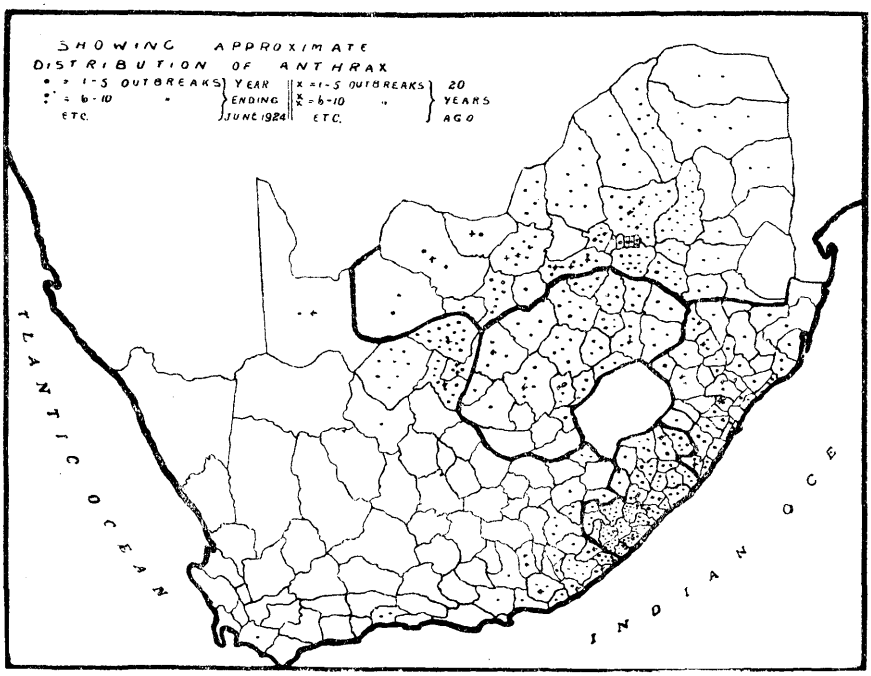
These statistics show in a most emphatic way the widespread distribution of anthrax, but a better idea is obtained of the geographical prevalence by diagramatic representation as shown in the following map:—



Position 18-19 Years Ago.—Having now obtained a good idea of the *present* distribution of anthrax, it is fitting that a survey be made concerning the position at the time shown by the earliest available records. These show that accurate records in the case of the Cape Province proper and Transkeian Territories were first kept nineteen years ago, and fairly reliable records in the case of the Orange Free State eighteen years ago. The position, however, is suitably summarized in tabular form as follows:—

TABLE VII.

Cape Proper.
1904-5.

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
Bedford.....	1	2	—	—	—	—	—	—	—	2	—	1	6
East London.....	—	1	—	—	—	—	1	—	1	—	2	—	5
Herbert.....	—	—	—	—	2	1	—	—	1	—	—	—	4
Kimberley.....	—	—	1	—	—	1	—	1	2	.	1	—	6
Komgha.....	—	1	—	—	1	—	—	—	—	—	—	2	4
Stutterheim.....	—	—	—	1	—	—	—	—	—	—	—	—	1
Albany.....	—	—	—	—	—	—	—	—	—	—	1	—	1
Barkly West.....	—	—	—	—	—	—	—	—	2	—	—	—	2
Fort Beaufort.....	—	—	—	—	—	—	—	—	—	—	2	—	2
Gordonia.....	—	—	—	—	—	—	—	1	—	—	—	—	1
Peddie.....	—	—	—	—	—	—	1	—	—	—	—	—	1
												TOTAL.....	33

Table VIII.

Transkeian Territories.

1904-5.

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
Umtata	—	1	—	—	—	—	—	—	—	—	—	—	1
Kentani	2	2	2	1	—	—	—	—	—	—	1	—	8
Nqamakwe	—	—	—	—	—	1	—	—	—	—	—	—	1
Willowvale	1	—	—	—	—	—	—	—	—	—	—	—	1
Kokstad	—	—	—	1	—	—	—	—	—	—	—	—	1
Matatiele	—	—	—	—	1	—	—	—	—	—	—	—	1
Tsolo	1	—	—	—	—	—	—	—	—	—	—	—	1
Libode	—	—	—	—	—	—	—	—	—	—	—	1	1
												TOTAL	15

Table IX.

Natal.

1905-6.

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
Newcastle	—	4	—	—	—	1	—	—	—	—	—	—	5
Estcourt	—	1	—	1	—	—	—	—	—	1	1	—	4
Umvoti	—	—	1	—	—	—	—	1	—	—	—	—	2
Dundee	—	—	—	—	2	—	—	—	—	—	—	—	2
New Hanover	—	—	—	—	—	—	—	—	—	—	—	1	1
Alfred	—	—	—	—	—	—	2	—	—	—	—	—	2
												TOTAL	16

Table X.

Orange Free State.

1905-6.

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
Bethlehem	—	—	—	—	—	—	—	—	—	—	—	—	1
Bloemfontein	—	—	—	—	—	—	—	—	—	—	—	—	1
Boshof	—	—	—	—	—	—	—	—	—	—	—	—	1
Thaba 'Nchu	—	—	—	—	—	—	—	—	—	—	—	—	1
												TOTAL	4

Table XI.

Transvaal.

* 1904-5.

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
Pretoria	—	—	—	—	—	—	—	—	—	—	—	—	11
Johannesburg	—	—	—	—	—	—	—	—	—	—	—	—	
Krugersdorp	—	—	—	—	—	—	—	—	—	—	—	—	
Lichtenburg	—	—	—	—	—	—	—	—	—	—	—	—	
Potchefstroom	—	—	—	—	—	—	—	—	—	—	—	—	
Mafeking	1	1	—	—	—	—	—	—	—	—	1	—	3
Vryburg	—	—	—	1	—	—	—	—	—	—	—	—	1
												TOTAL	15

* For the sake of uniformity the regions are considered from the present veterinary administrative aspect.

It will be noticed that the earliest available records of outbreaks according to district are those of 1904-5, except in the case of Natal and the Orange Free State when 1905-6 is the first record obtainable.

It is quite obvious from a perusal of the above figures that not only has there been a remarkable extension of the disease into new districts, but also an extraordinary increase in prevalence. The outbreaks referred to in the above tables are diagrammatically shown in the map on page 447.

II.—*Factors Influencing the Maintenance and Spread of Anthrax.*

In the preceding pages it has been shown that anthrax is widespread in this country, but that its distribution is very unequal. It now remains to discuss the environmental and other factors which in some way or other determine or influence the relative frequency of the disease in different parts of the country.

While there cannot be any doubt that the carcasses of animals that have died from anthrax must always be considered the main source of infection, it would be unwise to ignore completely the possibility of the organisms being able to multiply outside the body. One of us—Viljoen (1924)—had previously drawn attention to the fact that the biology of *B. anthracis* under natural veld conditions was completely unknown, and until out knowledege in this connection was vastly improved, there could never be any certainty of eradicating the disease from any locality. In some parts of Europe the organism is believed to be a strict obligatory parasite, but this belief is based purely on circumstantial evidence. Whether or not the anthrax spores are able to vegetate and multiply in the soil, especially under our warm South African conditions, has never been settled by direct experimental evidence. This important point may have considerable bearing on the local prevalence of anthrax, but until it is decided in one way or another it will not be possible to pronounce an accurate judgment on the relative importance of the different environmental and other factors. These factors may be considered under the following headings:—

(1) *Topographical and Pastoral Conditions.*

While in European countries the occurrence of anthrax is often connected with low-lying, marshy places, the same relationship cannot be said to exist in this country. The disease is prevalent both on wet and dry pastures, so that apparently very little importance can be attached to the moisture contained in the soil.

Standing water, however, undoubtedly plays a big rôle in some cases, and this is particularly the case in the drier parts of the country where watering facilities are inadequate. What happens in these cases is that large numbers of stock concentrate at the watering places, stir up the little water there is, thus giving any anthrax spores that may be present in the muddy deposit every opportunity of being taken in by the animals. Deaths from anthrax commonly occur in or near the water of small pans, etc., so that infection of such water is not infrequent. This has been proved on several occasions by bacteriological investigation of samples of suspected water.

Regarding the nature of the pasture, there appears to be every likelihood of it having some bearing on the spread of the disease. To South African veterinarians it is well known that anthrax most commonly occurs in " grass " country, and only rarely on purely

" Karroo " veld, where the animals have to exist, very largely on small shrubs. Apart from the difference that on grass veld the animals generally graze very close to the ground (and in so doing must unavoidably ingest quite an appreciable amount of soil), whereas on Karroo veld the stock fed on the succulent parts of the shrubs which are some distance from the soil (and are not so easily contaminated with anthrax spores), the possibility that anthrax organisms cannot live in the particularly arid Karroo must also be considered.

Concerning the factors influencing spread of anthrax, one other aspect has to be borne in mind, and that is the lack of facilities for burning or burial of carcasses. In some districts no firewood is available and the soil is of such a stoney nature that digging large holes becomes impossible; in such cases the proper disposal of carcasses cannot be carried out.

(2) *Climatic Conditions.*

These will be discussed more fully under " seasonal prevalence," but, apart from rainfall, it may be mentioned that anthrax is equally prevalent in the colder and warmer parts of South Africa. Mention has been made of the fact that anthrax is not prevalent in the central parts of Africa, but there seems to be no reason to believe that the warm climatic conditions are in any way responsible for this. Actually in this case it would appear that the disease has not been introduced to any extent, in other words, it would seem that anthrax is generally a " disease of civilization."

(3) *Class of Farmers.*

This is one of the most important factors to be considered when the relative prevalence of anthrax comes up for discussion. Successful control of the disease must to a large extent depend on the care which is taken in the disposal of infected carcasses, and since this work cannot be supervised by State officials it must of necessity be left in the hands of the farmer. Proper disposal of infected carcasses will, therefore, depend on the class of farmer; if he happens to be a careful and conscientious man proper control in this direction will be exercised, whereas if he is of the casual or careless type nothing will be done.

In South Africa, like in all other countries, there are both types of farmer, but there is unfortunately a further complication, namely, the native who, generally speaking, is careless in his farming methods and, above all, does not understand food hygiene. With him it is a common practice to skin a dead animal, no matter what disease it died from, and to consume the meat. If the animal happened to have died of anthrax, infection derived from the skin, meat, bones, offal, etc., would be spread far and wide. This factor would explain the excessive prevalence of anthrax in some parts of the country, such as in the Transkeian Territories, Eastern Province of the Cape, etc. On the Witwatersrand there are no native stock owners, but a large native population finds employment on the gold mines; meat of any sort finds a ready sale among them, and this gives rise to unscrupulous persons skinning carcasses of animals no matter what they died of. This factor is undoubtedly responsible, if only in part, for the excessive prevalence of anthrax in that area, to counteract or eliminate which special regulations have had to be drawn up. Careless stock owners, whether European or native, are therefore a menace not only to their neighbours, but also to the whole community.

(4) *Class of Stock.*

That the class of stock farmed in any particular locality influences the maintenance and spread of the disease is quite clear. Although we have no statistics to show the relative prevalence of anthrax in different species of animals, there can be little doubt that cattle are the principal sufferers. There are, of course, exceptions, such as are met with in localities where the disease is transmttied in a special manner; for instance, in Griqualand West horses are commonly infected by the horsefly. Generally speaking, anthrax is most prevalent in areas where cattle farming is carried on. It must be made clear, however, that the class of animals farmed in any particular area very often depends largely on the type of veld, and this factor has also to be considered. As an example, we may take the Karroo, previously referred to, which is pre-eminently a sheep country and where very few cattle are kept. Anthrax is practically unknown there, but, as explained previously, this may not be due to the absence of cattle but to the arid nature of the country.

Furthermore, there are many areas where farming with both large (cattle and equines) and small stock (sheep and goats) is carried on. Here the remarkable observation has often been made that an outbreak of anthrax may be confined to only one species, and this in spite of the fact that the different species of animals run under exactly similar conditions having access to the same pastures, water supply, etc. In some cases only cattle or horses are attacked, while in others sheep or goats are the only sufferers. With our present knowledge it is impossible to find a correct explanation for this phenomenon. Attention must be drawn to the fact that cases of anthrax in small stock are more likely to remain unrecognized and undiagnosed, not only because of their smaller value, but also because of the greater difficulty in arriving at a diagnosis. Many cases are known to the writers where no notice was taken of sporadic cases in sheep and goats, but the owners sought advice only when deaths commenced to occur on a large scale. It should be explained that the diagnosis of anthrax in small stock offers special difficulties to the farmer owing to the existence of several well-known diseases which develop and terminate in the same sudden manner as does anthrax. As sources of further infection, these sporadic cases in small stock constitute a great danger, not only because they often go unrecognized, but also because the carcasses may not be found in the veld and are not submitted to a process of destruction. This is almost certain to happen when the disease breaks out in susceptible species of game that are also kept on the farm.

Two interesting charts, showing the relative distribution of (*a*) cattle and (*b*) sheep and goats, are shown at end of this article.

(5) *Insect Carriers.*

Under this heading will be mentioned particularly the common horsefly (*Hippobosca rufipes*), which is present in thousands in certain parts of the country. These flies are widespread in South Africa, but they are especially prevalent in some of the drier areas—western Orange Free State and Griqualand West. They seem to be present practically all the year round, but become particularly numerous during the spring and early summer months. Hippobosca appear to favour equines, because even if other species of animals (cattle, sheep, etc.) run on the same farm they are relatively free from the attacks of

the fly. On horses they appear in their thousands, and settle particularly on parts of the body not well protected by the hairy coat, such as between the thighs, along the perineum, on the udder of the mare, or sheath of the stallion or gelding.

As long ago as 1892, Henning expressed the opinion that horse-flies might be responsible for the transmission of anthrax in equines. From our recent observations there appears to be very little doubt that this is actually the case, *B. anthracis* having actually been isolated from flies removed from horses infected with the disease. Transmission experiments were actually started, but owing to lack of suitable material had to be discontinued. The following field observations provide strong evidence, although only circumstantial:—

(*a*) The flies only attack horses on any large scale, and usually the disease is confined to these animals, although cattle and sheep may be running together in the same veld.

(*b*) The anthrax swellings have been observed to commence on the places where the flies cluster together and extend from there gradually to the adjoining parts. When once the swelling has become well developed, other symptoms of anthrax, such as fever, dullness, etc., become noticeable.

(*c*) The disease occurs in epizootic form only at the time when the flies appear in swarms on the animals, i.e. the summer.

The Hippobosca is a slow feeder, remaining on its host for long periods, and apparently mechanical transmission is possible only when there are numerous flies, some of which contain the infection. The outbreak usually starts in a sporadic manner, only a few equines being affected; the flies then become infected—and it is noteworthy that they swarm particularly on sick animals—and apparently carry the disease to other horses; the more cases of the disease there are the more flies become infected, with the result that the disease assumes an epizootic form. In these areas it was not unusual for 50 to 60 per cent. of horses on the farm to succumb to the disease in a few weeks' time. It should be mentioned that watering-places are an additional factor in these cases; the horses have to congregate at one or two small water-holes or dams, and here a further opportunity is given to the flies to select new hosts.

(*d*) Further evidence to support fly transmission is afforded by the fact that if horses on the farm are rendered insusceptible by vaccination carried out before the summer, the disease does not make its appearance; in this case other sources of infection still remain and other susceptible animals—cattle, sheep, etc.—are available.

(6) *Carrion Feeders.*

Animals that come up for special consideration are vultures, jackals, and dogs. Vultures used to be almost ubiquitous in this country, but during recent years have disappeared to a large extent. In the earlier days the pernicious custom of dragging carcasses some distance from the homestead and leaving them there to disintegrate prevailed to a large extent, and vultures which were abundant then largely assisted the process of disintegration. This lack of care in the

proper disposal of carcasses is still met with in some places, and one has no hesitation in saying that the increased prevalence of anthrax can be attributed largely to this factor.

As will be seen elsewhere in this report, vultures possess a strong natural immunity against anthrax, so that they can consume infected meat with impunity. Not only that, but anthrax spores are passed out intact with the faeces, so that in their droppings the infection can be spread far and wide. Moreover, vultures are often so hungry that they gorge themselves and later, by the natural act of vomition, get rid of the excessive material. This they will often do some distance away from the carcass, and it will readily be understood how easily infection is carried.

Both jackals and dogs have a high degree of resistance to anthrax, and they often consume infected meat with impunity. They will spread infection not only in their droppings, but also by means of infected meat which they are wont to carry long distances. In localities where these carrion feeders are present they must be considered an important factor in the maintenance and spread of anthrax infection.

(7) *Animal Products.*

In South Africa the trade in hides and skins constitutes an important factor in the spread of anthrax. As previously mentioned, there are careless farmers, especially native stock owners, who will remove the hides and skins from the carcasses of animals no matter what they died from. If the cause of death happens to have been anthrax, the infection is spread on the farm during the skinning process and to other places to which the infected material is carried. The infection in this kind of material may remain alive for years, anthrax spores being recoverable from products manufactured from it. Consignments of shaving brushes from Japan have been proved to be infected, while in South Africa it is by no means rare to demonstrate the presence of anthrax spores in riems made from hides.

Bone-meal is being used on a large scale in South Africa both for feeding stock and as a fertilizer, and for the purpose of manufacture of this article bones are collected—even unearthed—from all parts of the country. There is no doubt that quite an appreciable percentage of these bones contains anthrax spores, and that during transport to the factory the infection is spread to different places. The bone-meal itself, although sold as sterilized, is not always safe; only recently a case has come to our notice where a severe mortality in pigs could be traced definitely to anthrax contracted from bone-meal alleged to have been sterilized according to existing regulations.

From these few remarks it becomes quite clear that anthrax is often spread by means of animal products, and that the danger is particularly great in parts of the country inhabited by natives.

(7) *Animal Transport.*

In the earlier days, railway communication in South Africa was extremely limited, and animal transport, particularly draught oxen, had to be employed very extensively. Even at the present time there are vast areas where railway or mechanical transport is not available and where the trek-ox has to be called upon to get the farmers' produce to the nearest market. In nearly all serious epizootics in this country animal transport has largely been responsible for the spread of infection; in this connection one need only think of the alarming outbreak

of rinderpest in 1896 and of the rapid spread of East Coast fever during 1902 and 1903. To counteract this important factor, the permit system, regulating the movement of cattle and ox transport, had to be introduced in 1906 in the Transvaal. Animal transport is also largely responsible for the spread and increased prevalence of anthrax in some parts of the country. It often happens that draught oxen pick up infection, are moved during the incubation period, and succumb to the disease along the road, particularly at "outspans" or recognized halting centres. It often happens that carcasses of such animals are left along the road or, worse still, that natives skin them, remove the hides, and consume the meat.

The veterinary administrative authorities have appreciated this danger for a long time, and recently have enforced in badly infected areas special regulations whereby oxen employed for draught purposes in such areas must have been vaccinated against anthrax within the preceding twelve months.

(9) *Lack of Veterinary Supervision.*

In a country like South Africa, with its vast and thinly populated areas and with its ignorant native population, proper veterinary supervision is not possible in all cases. Although under the Stock Diseases Act excellent regulations for dealing with the different notifiable diseases exist, it is practically impossible to see that these regulations are carried out. What is specially lacking is the notification of new outbreaks, and this is due either to ignorance or gross carelessness on the part of the stock owner.

In the case of anthrax, where very often only sporadic cases make their appearance, the danger is particularly great, because such cases are likely to go unrecognized. In East Coast fever areas the regulations have had to be enforced very strictly, compulsory notification being made in each instance and blood-smears from every sick or dead animal submitted to microscopic examination. By these means the diagnosis of anthrax has incidentally been placed on a secure footing, and many cases of the disease which would otherwise have remained undiagnosed have been recognized in those areas. It is partly owing to this fact that the disease appears to have increased so enormously in some areas during recent years; for example, in the Transkeian Territories.

As pointed out elsewhere, anthrax does not seem to have become more prevalent in Natal during the last few years, and this may be due to strict veterinary supervision which has been in force for some years, and is still being carried out in connection with East Coast fever. Under the East Coast fever regulations animal transport and movement of cattle have been curtailed enormously, besides which better railway facilities exist.

In judging the relative prevalence of the disease and its apparent increase in the different areas, one must not overlook the extent to which it has been possible to exercise veterinary control in such areas.

III.—*Seasonal Prevalence.*

In regard to this question Kehoe (1919) pointed out that on account of defective reporting of outbreaks in South Africa it was impossible to bring forward any statistical evidence to show the existence of any special seasonal prevalence. We admit that even

now all outbreaks of anthrax are not reported, but submit that the available evidence tends to confirm the experience made in other parts of the world, namely, that the disease is more prevalent during the summer months.

In this connection Sinclair (1922), writing of Southern Rhodesia, states:—" Virulent outbreaks are frequently observed after a hot dry spell following heavy rains or flooding."

Tissie (1924), at the Fifth Pan African Veterinary Conference, in reference to anthrax in Madagascar, made the following statement:—" There are two seasons during which the disease usually occurs. Firstly, the end of the rainy season, February and March, during which periods the rivers which have overflowed their banks come back to normal and leave open vleis. . . . Secondly, the end of the dry season, November and December, when the grazing is very dry. . . . The dried-up vegetation injures the first portion of the alimentary tract of cattle already weakened by shortage of food, excoriations . . . afford easy access to anthrax spores."

With regard to South Africa, it is significant that all the serious outbreaks which we have been called upon to investigate have occurred during the summer months, i.e. the rainy season in most parts of this country. Further information on this point is obtained from (*a*) official returns showing the monthly outbreaks of the disease and (*b*) figures relating to the issue of anthrax vaccine.

With regard to the former, full details concerning monthly outbreaks in the various districts of the Union for the year ended June, 1924, will be found on pages 444-6. The summer season may be taken to commence in October and end in March, while the winter season includes the period between April and September. Adding together all outbreaks which occurred during the summer months and those which were reported during the winter months of the year ended June, 1924, the following results are obtained for the different administrative areas:—

Veterinary Administrative Area.	Total Outbreaks: Summer Months.	Total Outbreaks: Winter Months.
Cape Province	219	97
Transkeian Territories	294	188
Natal	76	30
Orange Free State	151	93
Transvaal	387	277
TOTALS	1,127	685

These figures are striking, showing that in all cases the outbreaks which occur during the summer months far exceeds those of the winter months; when the total is taken the evidence becomes even more convincing, the summer outbreaks being nearly double those of the winter.

It may be argued that notification of outbreaks is defective and that consequently these figures are not accurate; this argument does

not hold good because there is no reason to believe that notification will be any more defective during the winter than the summer months. It is safe to assume that the relative frequency of the disease during the summer and winter seasons is indicated fairly accurately.

While discussing this point, one is immediately faced with the difficulty of offering a satisfactory explanation of the increased prevalence during the summer months, i.e. the rainy season in the areas concerned.

It may be that under favourable conditions, i.e. heat and moisture during the summer months, the organisms are able to multiply, but against this stands the fact that anthrax is equally prevalent in the colder climate of Europe, and that in the Western Province of the Cape, where the rainy season is during the winter months, the disease is practically unknown. On the other hand, an explanation may be looked for in the flooding which occurs during the summer rains; the loose surface soil is washed away and it is reasonable to assume that anthrax spores contained in the soil are brought to the surface in this way. Not only that, but there is a tendency for loose surface soil from comparatively large areas to be washed down to the low-lying parts, e.g. valleys, streams, spruits, small dams, etc. In this way there is a concentration of anthrax spores, thus greatly increasing the chances of animals becoming infected.

Concerning the second point, namely, the monthly issue of anthrax vaccine, the evidence is not so satisfactory, because vaccine is often asked for and inoculation performed when no actual outbreak of the disease has occurred. Some of our farmers have been taught to use the vaccine purely as a means of prevention and to inoculate their stock before the disease actually makes its appearance on the farm. Others have not learnt this lesson and still delay inoculation until anthrax has actually broken out among their stock. The following table shows the monthly issue of vaccine during the summer and winter seasons ended March, 1925:—

TABLE XII.

Winter Months.	Vaccine Issued.	Summer Months.	Vaccine Issued.
April	161,010	October	125,270
May	119,850	November	88,350
June	90,520	December	189,670
July	99,770	January	328,745
August	191,710	February	279,250
September	182,810	March	228,410
TOTAL FOR WINTER	845,670	TOTAL FOR SUMMER	1,239,695

It will be seen that the summer issues are much greater than those made during the winter, but that preventive inoculation goes on steadily all the year round. The figures also show that there is a big demand for vaccine during the late winter and spring months, August to October, the reason being that inoculation is resorted to before the period during which outbreaks of anthrax most commonly and frequently occur.

IV.—*Occurrence in Industry.*

This side of the anthrax problem has to be referred to briefly, since the veterinarian is as much concerned in the prevention of infection in human beings as is the medical man. As a matter of fact it is mainly owing to its occurrence in certain industries that anthrax has received so much attention recently. The position was considered to be so serious that it received the special attention of the International Labour Organization, which was established as an institution of the League of Nations by the Treaty of Versailles. A commission appointed by the Washington Labour Conference in 1919 recommended in connection with occupational diseases the formation of a health section in their organization. In addition, it suggested that both disinfection and further research should be undertaken in connection with animal products infected with anthrax and used in industry.

At the Geneva Labour Conference in 1921 the question of anthrax infection in animal products, particularly wool, again came up for discussion, and an advisory committee was appointed to investigate this problem very thoroughly. This committee met in London during December, 1922, when they made certain recommendations which are well known and need not be recapitulated here.

In South Africa there are comparatively few industries which handle raw animal products, and consequently anthrax is rarely heard of in these circumstances. This does not mean that the disease does not occur in human beings; on the contrary, it is by no means rare, especially in natives.

The following table shows the number of cases officially notified to the Department of Public Health during the last few years:—

TABLE XIII.

Period.	European.	Native.
1920	31	44
1921	17	93
January–June, 1922	13	28
July, 1922–June, 1923	11	39
TOTAL OVER 4½ YEARS	72	204

These figures are only approximate, as undoubtedly many cases, especially in natives, are not reported officially.

In the large majority of cases the disease is contracted either when skinning infected carcasses or from the consumption of diseased meat. As mentioned elsewhere in this article, it is a common occurrence for carcasses of animals that have died of anthrax to be skinned and cut open by ignorant or careless Europeans and natives; in the case of Europeans, the skin is required for trading or private use, while the natives want both the skin and meat. A few cases are contracted from handling carcasses of animals that have been killed in the slaughter-houses. In these cases the animals suffer from a subacute attack of the disease which is not recognized by the lay-

inspector or butcher. With proper ante- and post-mortem inspection by a veterinarian it is unlikely that such cases will be passed through the slaughter-house

As far as we know, no cases of anthrax in human beings have so far been reported as originating in a factory. Among the few existing industries the following are perhaps worth mentioning: tanneries, fertilizer and bone-meal plants, and wool factories.

Hides and skins used in the tanneries and bones employed in the manufacture of fertilizer and bone-meal are collected on farms in different parts of the country and usually sold to the nearest dealers or storekeepers. From here they are railed, or sent by road transport, to the nearest factory or else to one of the ports for export. All this necessitates a great deal of handling by workmen, who stand a certain amount of risk of contracting the disease from any infected material that may be present. Fortunately, owing to the dry state in which the skins and bones are transported, the risk of infection is not very great. We have previously drawn attention to the importance of these animal products as a factor in the spread of anthrax infection.

In the tanneries themselves the risk run by workmen is of course much greater, since a good deal of handling must necessarily be done and since the anthrax spores are not destroyed during the tanning process. In the case of wool, the danger of spreading infection during transport is not so great, because it is conveyed in packs, generally of hessian. The greatest risk of human beings contracting the disease occurs during sorting at the factory. The infection of wool is derived from sheep that have died of anthrax; wool removed from such sheep is infected and may contaminate other wool in the pack. It is doubtful whether much of this class of wool will reach our factories, which are only in the early stages of development and run on a comparatively small scale. At a later stage of ths report reference will be made to measures that are taken to protect workmen employed in industries dealing with raw animal products.

D.—Occurrence in Animals and Methods of Infection.

Under this heading will be discussed not only natural infection, but also species and individual susceptibility to artificial infection.

Regarding natural infection of animals under South African conditions, it must be pointed out at the outset that no statistics are available to show accurately the relative frequency of anthrax among domestic animals. Judging by the results of blood-smear examination, one would have no hesitation in saying that cattle are the worst sufferers, but this evidence is not altogether reliable, because blood-smears from the smaller animals, sheep and goats, are not submitted to microscopic examination so frequently and with such regularity as those from cattle. The reason for this is that owing to the existence of East Coast fever in some areas the taking of blood-smears from all sick and dead cattle is made compulsory under Government regulations. Not only that, but farmers are encouraged to send blood-smears from cattle by reason of the fact that diagnosis of other diseases (piroplasmosis, anaplasmosis, etc.) is often made possible. Apart from anthrax, blood-smear examination is of little assistance in arriving at a diagnosis of other diseased conditions in sheep and goats. Moreover, generally speaking, cattle are of greater value to the farmer than sheep and goats, with the result that he is often more

concerned about the loss of one cow than of half a dozen sheep or goats. In practice it follows that sporadic cases in the latter are often not taken any notice of, no suspicion of anthrax crossing the mind of the farmer. Judging by the relative numbers of cattle and sheep in the Union, it would be safe to conclude that the incidence of anthrax is comparatively greater in the first mentioned.

Further information in connection with the relative frequency of the disease in the different domestic animals may be looked for in the amount of vaccine issued for use in each species, but unfortunately no separate records are kept in respect of vaccine used in cattle and sheep respectively. The following table, showing vaccine issues during the twelve months ended March, 1925, will give some idea of the extent to which vaccination is carried out in equines and goats, compared with that in cattle and sheep combined:—

TABLE XIV.

Month.	Cattle and Sheep.	Equines.	Goats.	Totals.
1924.				
April	142,000	15,710	3,300	161,010
May	113,690	5,440	720	119,850
June	83,605	6,635	280	90,520
July	87,615	9,755	2,400	99,770
August	167,850	21,760	2,100	191,710
September	167,710	14,500	600	182,810
October	116,990	7,440	840	125,270
November	80,100	7,350	900	88,350
December	176,000	7,400	6,270	189,670
1925.				
January	304,785	3,860	20,100	328,745
February	261,000	14,250	4,000	279,250
March	209,010	14,600	4,800	228,410
TOTALS	1,910,355	128,700	46,310	2,085,365

These figures show to what an enormous extent vaccination is carried out in cattle and sheep, the amount of vaccine used per annum in these animals being nearly twelve times that utilized in the inoculation of equines and goats. The total horse and goat population in the country is considerably smaller, and this has to be taken into account. As mentioned earlier in this paper, only certain parts of the country are suitable for horse breeding, so that serious outbreaks of the disease in equines must be looked for only in certain well-defined areas. Incidentally the climatic and other conditions in some of these areas are also very favourable for the breeding of horse-flies, which we believe to be largely responsible for the transmission of anthrax in equines; the result is that unless preventive inoculation is practised systematically the disease is likely to break out in epizootic form. Equines are also kept mainly for transport purpose on nearly every farm in the Union and in or near big towns, and cases of anthrax are not by any means rare in these cases.

Practically the same remarks may be made in connection with the distribution of the goat population in the Union. They suffer from anthrax in the same way as sheep, i.e. the disease occurs in a septicaemic form, cases commonly occurring in a sporadic manner. No definite data are available to show the relative frequency of anthrax in goats, but the impression exists that goats suffer less than sheep. This may be due to their feeding habits, goats being known to live largely on the leaves of trees and shrubs. That they are extremely susceptible to the disease will be seen later.

In this country anthrax in pigs is not very common, although several outbreaks have been investigated officially; as in other countries, the disease is contracted from ingestion of infected animal products; one such outbreak which occurred as the result of feeding on infected bone-meal has already been referred to.

The occurrence of anthrax in the ostrich need not be discussed, since it was fully dealt with by Kehoe in 1919.

On badly infected farms cases of anthrax occur fairly commonly in wild herbivora; in a few outbreaks in domestic animals investigated by the writers severe mortality was observed in hartebeest and springbok running on the infected farms, anthrax being diagnosed in some cases by bacteriological investigation.

Regarding the order of susceptibility of the different species of animals as determined by artificial infection, interesting observations have been made, chiefly in connection with experiments to determine the M.L.D., but also with vaccine tests. To begin with, it may be recorded that white mice and guinea-pigs are extremely susceptible to both virulent and attenuated anthrax strains, and that no well-marked variation in susceptibility of individuals has been encountered. This makes these laboratory animals particularly useful in anthrax work. Rabbits possess a great deal more natural resistance against anthrax, but they can invariably be killed by using a sufficient amount of virulent material, while properly attenuated strains are tolerated well. For these reasons the rabbit also is a very useful animal in anthrax work, especially for tests carried out in connection with the safety of vaccines, as will be seen later.

Of the domestic animals, the sheep (we invariably worked with the merino breed) is the only one in which individual susceptibility does not play an important part. Now and again one meets with a sheep that shows abnormally developed individual susceptibility or resistance, but, generally speaking, when the species-susceptibility has been determined, it will also hold good for individuals, no matter where they come from. It will be seen later that in some other species, individuals reared in one part of the country have been found to be more susceptible than animals from another part.

In sheep the M.L.D. of virulent anthrax has been determined as .0001 c.c. of undiluted spore emulsion of batch now in use; this indicates that this species is very susceptible to virulent anthrax. On the other hand, sheep are very resistant against the injection of our vaccine strains, and in this character again there is no well-marked variation among different individuals. In our safety and immunity tests carried out in connection with spore vaccine we invariably inject as much as 20 c.c. of the concentrated emulsion into sheep, and so far only two animals have been killed by these means. When it is stated that 20 c.c. may represent about 4,000 doses of vaccine as used in practice, it will be realised to what extent this resistance

exists. As will be seen later, the sheep is an extremely good subject to immunize against anthrax. Taking all these factors into consideration, one has no hesitation in recommending the sheep as the most suitable animal to use in anthax experiments.

Coming to the other domestic animals, we find an extraordinarily great variation in susceptibility, not only amongst individuals but also among groups of the same species from different localities. These remarks apply particularly to goats and horses.

In South Africa two breeds of goats are met with, namely, (*a*) the angora and (*b*) the native breed, commonly called "Boer" goat. There is no reason to believe that these breeds would show any great difference in their relative susceptibility to anthrax, but it should be mentioned that in our work the Boer goat was employed.

As a species the goat shows extraordinarily marked susceptibility to anthrax, much more so than the sheep. This susceptibility was first brought to our notice as a result of mortality which occurred in goats after inoculation with the ordinary vaccine used for sheep. Goats were then included in our experimental animals and we soon found that a vaccine which although absolutely safe for use in sheep produced mortality in goats, varying from a few to 30 or 40 per cent. of the inoculated animals. The following cases will serve to illustrate this point:—

(*a*) In November, 1921, twenty goats were inoculated with spore vaccine imported from Australia and of this number five died as the result of vaccination, i.e. a mortality of 25 per cent.

(*b*) In January, 1922, six goats were inoculated as in (*a*), with a resulting mortality of 33½ per cent.

(*c*) In August, 1922, this vaccine was again injected into fifteen goats, with the result that three died, a mortality of 20 per cent.

(*d*) The experiment mentioned under (*a*) was controlled by the use of locally prepared vaccine at the same time and in the same number of goats.

The result was that two deaths occurred, i.e. 10 per cent.

(*e*) In August, 1923, fifty-eight goats were treated with locally prepared single vaccine and of this number five died, i.e. a mortality of 8.6 per cent.

(*f*) On the same date as mentioned under (*e*) sixty-six goats were injected with locally prepared double vaccine, the resulting mortality being 9 per cent.

From these few instances it becomes quite clear that the ordinary vaccine (local or imported) intended for use in cattle and sheep is by no means safe to employ in goats. It may be mentioned that the same vaccines referred to above had been used extensively in sheep, and that no ill effects were ever experienced.

With the further experience gained in experimental work on goats, we soon began to realize that this peculiar susceptibility did not apply to all goats; in other words, evidence was obtained to show that the heavy mortality resulting from vaccination was mainly due to exceptional suceptibility displayed by some individuals. To illustrate this, special instances have been selected from tests carried

cut in connection with different vaccine batches, and these are shown hereunder:—

Experiment.	Batch.	Goat Received.	Result.	Sheep Received.	Result.
1406	20	·005 c.c. glyc. emulsion	+ Anthrax	20 c.c. glyc. emulsion	Lived.
1423	22	·1 „ „ „	„	20 „ „ „	„
1463	24	·1 „ „ „	„	20 „ „ „	„
1560	33A	·1 „ „ „	„	20 „ „ „	„
1583	37	·01 „ „ „	„	20 „ „ „	„
1584	38	·01 „ „ „	„	20 „ „ „	„
1783	44	·1 „ „ „	„	20 „ „ „	„
1783	44	·01 „ „ „	„	20 „ „ „	„
1784	45	·01 „ „ „	„	20 „ „ „	„
1834	46	·005 „ „ „	„	20 „ „ „	„
1835	47	·01 „ „ „	„	20 „ „ „	„
1903	50	·01 „ „ „	„	20 „ „ „	„
1903	50	·005 „ „ „	„	20 „ „ „	„
1905	52	·005 „ „ „	„	20 „ „ „	„

+ Equals dead.

It will be seen that some goats which had received comparatively small doses of vaccine died from the effects, whereas all sheep which had received as much as 20 c.c. of the same material survived. Other goats (not shown here) which had received *much bigger doses, up to* 10 *c.c. also survived,* thus indicating that specially marked susceptibility is only present in some individuals. In other species of animals specially susceptible individuals are also known, but their number is comparatively small. In the goat this marked susceptibility is observed in so many individuals, up to as many as 30 per cent., that one is inclined to put everything down to "species suceptibility." In practice from the vaccine maker's point of view, it amounts to the same thing, because the vaccine issued for use in goats must be safe for all, including the exceptionally susceptible individuals. This side of the problem will receive further consideration at a later stage. Finally, we may compare the susceptibility of the goats to that of other species, particularly small laboratory animals. The point at issue can again be illustrated best by selecting special cases from ordinary routine tests carried out in connection with different vaccine batches. Here, of course, the exceptionally susceptible goats have again been chosen. The results are shown hereunder:—

Batch.	Guinea-pig.	Result.	Goat.	Result.	Rabbit.	Result.	Sheep.	Result.
20	·1 c.c.	+ Anthrax	·1 c.c.	+ Anthrax	—	—	·1 c.c.	Lived.
22	·1 „	„	·1 „	„	—	—	·1 „	„
24	·1 „	„	·1 „	„	·1 c.c.	Lived	·1 „	„
33A	·1 „	„	·1 „	„	·1 „	„	·1 „	„
37	·01 „	Lived	·01 „	„	·1 „	„	·01 „	„
38	·01 „	„	·01 „	„	·1 „	„	·01 „	„
44	·1 „	+ Anthrax	·1 „	„	·1 „	+ Anthrax	·1 „	„
44	·01 „	„	·01 „	„	·01 „	„	·01 „	„
45	·01 „	„	·01 „	„	·1 „	Lived	·01 „	„
46	·01 „	„	·01 „	Lived	·1 „	„	·01 „	„
47	·01 „	„	·01 „	+ Anthrax	·1 „	„	·01 „	„
50	·01 „	„	·01 „	„	·1 „	„	·01 „	„

All doses are of the glycerinized emulsion of undiluted vaccine.

+ Equals dead.

It will be seen that in these instances the goat proved to be as susceptible as the guinea-pig, the same dose sufficing to kill both in most cases. In two instances goats died from the same dose of vaccine that failed to kill guinea-pigs. It must be remembered that the size or weight of the animals was not considered at all, so that if one had to calculate the lethal dose of vaccine on a weight basis, the goat would have to be considered even more susceptible than the guinea-pig. Only two rabbits died in these tests and both from the effects of one particular vaccine which was found to be exceptionally strong. None of the sheep showed any ill effects. Owing to the excessive expenditure that would be involved, it was not possible to determine accurately the M.L.D. of anthrax in either equines or bovines. With the few experiments that we were able to carry out, a most determined resistance to artificial infection was encountered in both species. This is illustrated as follows:—

Experiment No. 1.

Species.	Method of Infection.	Dose of Virulent Anthrax.	Result.
Equine	Subcutaneous	1 c.c. standard emulsion	Negative.
,,	,,	3 ,, ,, ,,	,,
,,	,,	10 ,, ,, ,,	+ Anthrax.
,,	,,	10 ,, ,, ,,	,,
,,	,,	10 ,, ,, ,,	Negative.
,,	,,	1 ,, agar slope	+ Anthrax.
,,	,,	2 ,, ,, slopes	,,
,,	,,	2 ,, ,, ,,	,,
Bovine	,,	5 ,, standard emulsion	Negative.
,,	,,	10 ,, ,, ,,	,,
,,	,,	1 ,, agar slope	,,
,,	,,	2 ,, ,, slopes	,,
,,	,,	2 ,, ,, ,,	+ Anthrax.
,,	,,	1 ,, ,, ,,	Negative.
,,	In drinking water	2 ,, ,, ,,	,,
,,	,,	3½ ,, ,, ,,	,,
,,	,,	2½ ,, ,, ,,	+ Anthrax.
,,	,,	¼ ,, ,, ,,	Negative.
,,	,,	½ ,, ,, ,,	,,
,,	,,	1 ,, ,, ,,	,,

+ Equals dead.

The M.L.D. of the standard emulsion used in these experiments had been determined in sheep and fixed at .001 c.c. for this species. A dose of 1 c.c. therefore represents 1,000 M.L.D. for sheep.

Although the experiments were not carried out on a sufficiently large scale it would seem that the M.L.D. for equines is about 10 c.c. or 10,000 M.L.D. for sheep. From this one might conclude that equines are relatively insusceptible to anthrax infection, but such a conclusion would not be borne out by practical experience in the field.

In cattle, these results are still more striking, apparently at least two agar slopes of virulent culture being necessary to produce fatal results. By ingestion it was possible to set up a fatal attack

in one animal, 2½ agar slopes having been administered in drinking water. Here again, one would be inclined to consider the ox relatively insusceptible to anthrax, but, as has already been indicated, in practice of all the domestic animals cattle appear to be the worst sufferers. Against these results stands the fact that in practice fatal cases have been produced in equines by the injection of such a small quantity of *attenuated virus* as 1 c.c.! One finds great difficulty in explaining this when experimentally it is possible to kill horses with anthrax only when comparatively large doses of virulent material are used. One can hardly conceive that cattle or horses under natural conditions would have to pick up such large quantities of anthrax spores, as represented by 10 c.c. spore emulsion or two agar slopes, before a fatal injection could be brought about, and yet in practice they seem to contract the disease easily enough. Apparently some unknown factors come into play, but before their true nature could be determined it would be necessary to have accurate knowledge of the natural method of infection.

Concerning this important matter—method of infection—no experimental data or accurate observations are available to show how animals normally contract the disease in nature. There are, of course, a few exceptions; for instance, we have already referred to an outbreak in pigs, definitely traced to ingestion of infected bonemeal; we have also mentioned that in certain parts of the country Hippobosca serve as transmitters.

In herbivora it is commonly accepted that the disease is contracted by the ingestion of infected material, but, as pointed out earlier, it is not easy to set up a fatal attack of anthrax by the administration of spores per os.

Recently much attention has been paid to the opinion expressed by Besredka (1921) and others that in the case of anthrax the skin is the only sensitive organ and that infection by this route follows even minute injuries to the skin. The following experiments in this connection are worth recording:—

Experiment No. 2.—July, 1924.

Sheep No.	Route of Infection.	Dose of Virulent Material.	Result.
		M.L.D.	
7331	Scarification of skin	100	Negative.
6869	,, ,,	100	,,
7316	,, ,,	50	,,
6306	,, ,,	50	,,
5730	Subcutaneous	100	Died.
623	Intradermal	100	,,
7095	Intra-mucosa-lip	100	,,
7315	,,	50	,,
7530	Sub-mucosa-palate	100	Negative.
7815	,,	50	,,
7442	Intravenous	100	,,
7519	,,	50	Died.

It need hardly be mentioned that when doing the intravenous, submucous and intravenous injections, every care was taken to avoid completely any contamination of the skin with anthrax spores

The results show clearly that scarification of the skin was not sufficient to permit of infection taking place. An experiment on similar lines was repeated as follows:—

Experiment No. 3.—*October*, 1924.

Sheep No.	Route of Infection.	Dose of Virulent Material.	Result.
		M.L.D.	
9596	Scarification of skin	250	Negative.
9523	,, ,,	100	,,
9612	,, ,,	50	,,
9580	,, ,,	50	,,
9489	Intradermal	100	Died.
9575	,,	50	,,
9508	Subcutaneous	100	,,
9570	,,	50	Negative.
7298	Intravenous	100	,,
9317	,,	50	Died.
9513	Intra-mucosa tongue	100	,,
9517	,, ,,	50	,,

The results show that all methods of infection, excepting scarification, were successful in producing a fatal attack of the disease. Apparently the standard virulent material was no longer as strong as when the M.L.D. for sheep was originally determined by the subcutaneous route; 50 M.L.D injected subcutaneously did not produce fatal results. It is clear, however, that the outer layers of the skin are not particularly sensitive to anthrax spores.

A further experiment with slightly more favourable results was carried out as follows:—

Experiments No. 4.—*October*, 1924.

Sheep No.	Route of Infection.	Dose of Virulent Material.	Result.
		M.L.D.	
9329	Scarification	500	Negative.
9471	,,	250	Died.
9500	,,	100	Negative.
9894	,,	100	Died.
9882	,,	50	,,
9121	Intradermal	50	,,
9394	,,	10	,,
7088	Subcutaneous	50	Negative.
9468	,,	10	,,
9550	Intravenous	50	Died.
9276	,,	10	,,

In this case application of the virulent material to scarified areas succeeded in setting up the disease in some cases, but special care was taken in making the scarified area larger and deeper, blood actually being drawn in the process.

Both sheep survived the introduction of the spores by the subcutaneous route, whereas infection by the intradermal and intravenous routes appear to be more certain than any others.

Conclusions.—From the results of these experiments one is justified in concluding that the outer layers of the skin are not specially sensitive to anthrax and that to ensure successful infection the organisms have to be introduced into the deeper layers of the skin.

Infection can easily be set up by introducing the organisms, (*a*) straight into the blood stream, (*b*) under the skin, (*c*) into and under the mucous membranes of the palate, lips and tongue. It appears to us, therefore, that the skin cannot be held to be the only sensitive organ. This matter will be discussed more fully when the question of immunity against anthrax comes up for consideration.

From these few remarks and experimental data it becomes clear that we are not yet in a position to explain the natural modes of infection in such animals as cattle and horses which experimentally appear to possess a great deal of natural resistance against the disease. The peculiar susceptibility which is sometimes displayed by some of these animals to small quantities of vaccine (attenuated spores) will be referred to again when the results of vaccination come up or discussion.

E.—Symptomatology.

Under this heading it is proposed to submit only a few remarks on special points that may be of general interest. Definite information is required on the incubation period and course of the natural disease in the different species of domestic animals, but this the authors are not in a position to supply. The experimental data available are mostly in connection with artificial infection by the subcutaneous route or have been obtained from experiments with attenuated organisms. Under field conditions cases of the disease come to the notice of the veterinarian only when symptoms are well developed or death has taken place, so that an opportunity for study is rarely available.

Under experimental conditions, when a lethal dose of virulent organisms has been injected subcutaneously, a temperature reaction is usually present in 48 hours, but the incubation period may be as long as three to four days in cases where barely one minimum lethal dose has been employed. There does not seem to be much difference in the time required for symptoms to develop in the various domesticated animals.

The course of the disease in small ruminants is very short, death usually taking place within three days after injection of virulent material. Sheep may survive four days, and rarely six to seven days in cases where very minute doses of virulent material have been employed.

Concerning cattle very little information is available, but in the subjoined temperature charts 535 and 536 the reactions following on infection per os will be found to be of interest.