

## The Study and Control of the Vectors of Rabies in South Africa.\*

By P. S. SNYMAN, Senior Veterinary Officer, Bloemfontein,  
Orange Free State.

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## PART I.

### INTRODUCTION.

IN most countries the epizootology of rabies is usually associated with the rabid dog only, and control measures are aimed at restricting the chance of spread of the disease by biting. Legislation, which is in all countries nearly alike, provides for the destruction of infected animals and for placing under strict veterinary observation of all those suspected of being infected. In order to have efficient control and to prevent the spread of the disease, large areas are proclaimed, and in these "rabies orders" are enforced. These orders aim at restricting the movement of dogs, eliminating stray dogs by licensing, and preventing dogs by muzzling from transmitting the disease. In some instances, furthermore, compulsory immunization of dogs is resorted to.

There are countries, where animals other than dogs play the main rôle in transmitting the disease and where the control problem assumes a totally different aspect. In parts of South America certain species of vampire bats *Phyllostoma superciliatum*, and *Desmodus rufus* in Trinidad, are the chief vectors of the disease, which occurs mainly in cattle. Outbreaks in these countries are remarkable for the disproportion between the small number of rabid dogs and the very large number of diseased cattle. In Trinidad alone during the years 1929, 1930, and 1931, the death rate averaged a thousand animals each year, and 90 per cent. of the animals affected were bovines. Only two cases were observed in dogs. It is obvious, that under these conditions checking the disease is very difficult, since bats cannot easily be destroyed in large numbers. Preventive measures have, therefore, to be resorted to. Metivier (1935) in discussing these measures mentions the construction of batproof cowsheds and stables, repelling the bats by bright illumination, and concludes that vaccination of animals is the most suitable method of control of the disease in Trinidad. Although the conditions and the vectors in South Africa are totally different, the problem nevertheless presents points of similarity with that in South America. In this country, the results of observations for the past ten years show that dogs play a negligible rôle in the dissemination of rabies, and that certain small wild carnivora are the vectors.

Snyman and Thomas (1939) in an exposition of the difficulties attending the control or destruction of these "wild carriers" pointed out that restraint of any kind on wild animals was out of the question, and that total eradication of any one or all of the species concerned in the dissemination of rabies could not be contemplated. Even if undertaken by the State, the cost of such a scheme would be prohibitive and it is doubtful whether anything more than a temporary reduction in numbers would result. It was suggested that extermination on a much reduced scale to include only centres of active infection and the immediately adjoining ground, might have the desired effect. It is clear from the mode of transmission they indicate, that if all infected animals as well as all susceptible ones, which might have come in contact with them are destroyed, the disease must

die out at that point as the virus cannot exist outside living animals. Should the area immediately become reoccupied by uninfected animals this would be of no consequence. The hope was expressed that by treating each successive outbreak of rabies in this fashion, that the incidence of rabies would gradually be reduced.

The peculiarities and difficulties of the problem, as regards the methods of control tried and finally adopted, as well as the experimentation which led up to them, form the subject of this paper.

## HISTORICAL.

### WRITINGS OF EARLY TRAVELLERS.

Reports on the existence of rabies in South Africa prior to the first authentic outbreak at Port Elizabeth in 1893 are scanty and rather contradictory. While Thunberg (1780) and Amicus (1825) referred to outbreaks of rabies, Barrow (1801) and Livingstone (1857) remarked on the absence of the disease in the country. An isolated outbreak of rabies was reported by Shepstone (1828) in Natal. In 1861 a case was reported at the Wittebergen in the Bethlehem district in "The Friend of the Freestate", a newspaper which circulated in the sixties.

The first authentic record of an outbreak of rabies in South Africa was written by Hutcheon in 1894. The outbreak, which was traced to an imported Airedale terrier, occurred at Port Elizabeth in 1893. The diagnosis was confirmed by subinoculation into rabbits and other animals. The disease spread to Uitenhage, Jansenville, Willowmore and Albany. A very significant statement was made by the Colonial Veterinary Surgeon, Dr. Hutcheon, that he feared lest the disease should be communicated to wild animals such as jackals, but except for the case of an ox, no cases other than in dogs and cats were observed.

Following the outbreak at Port Elizabeth, the disease next made its appearance in Southern Rhodesia in 1902. The incidence rate fluctuated, fewer cases being reported one year and more the following year. In 1911 a severe outbreak occurred again and in 1913 Sinclair, the Chief Veterinary Surgeon was able to report, that a marked decrease in the prevalence of the disease had occurred. Southern Rhodesia apparently remained free from 1913, and no further case was reported until last year (1938) when a positive one occurred on the Northern Rhodesian border.

As was the case with Hutcheon, Gray, the Principal Veterinary Officer, also feared that, owing to the wide distribution of the disease, it would spread to wild carnivora and so lessen the possibility of eradicating it altogether. A few cases were reported in wild carnivora, but in spite of that, it was actually brought under control.

It was only by drastic precautionary measures that the disease did not spread into the Transvaal, when outbreaks occurred near its border. In an area fifty miles wide in the Zoutpansberg district along the Bechuanaland and Southern Rhodesia borders the number of dogs was greatly reduced. Farmers were allowed only two dogs each. These had to be registered, and all stray dogs were destroyed.

The adjoining territories of Bechuanaland Protectorate and South West Africa are not entirely free from rabies. Hobday (1936) reported a case in a native child, and for precautionary measures dog-free belts were formed by destroying some 2,000 dogs.

In South-West Africa, owing to the vastness of the country and the absence of veterinary control in the native areas along the Angola border, the position has remained obscure for a long time.

In 1926 it was reported, that several natives died at a Mission Hospital in Ovamboland, with symptoms of hydrophobia, and a "history" of having been bitten by rabid dogs. From information gathered at an investigation, it would appear that the disease has existed there for the past twenty years.

Since 1926 suspected cases have been reported from Ovamboland and Okavango at various intervals. In 1935 the District Surgeon for that area reported, that a hyena entered a native kraal one night and attacked fowls, smashed pots and calabashes, and eventually attacked a native. He reports further that every year isolated cases of hydrophobia occur in natives, and for that year eighteen cases were reported, four coming under European supervision. He concluded, that on clinical grounds there exists no doubt that rabies is present in the area and that the chief carriers are dogs. Reports of rabies in domestic animals other than dogs, chiefly cattle, have also been made from Kuring Kurn in South West Africa.

In July 1938 the Native Commissioner for Okavango succeeded in obtaining the head of a dog, that had showed signs of rabies. "Material" in preservatives was dispatched to Onderstepoort, and a positive diagnosis of rabies was made. Commenting on the outbreak of rabies in that area the Native Commissioner states, that the natives have no love for or interest in their dogs, and merely keep great numbers of them to give alarm at night. Many of the dogs are seldom fed and never watered at the kraals, with the result that they wander from kraal to kraal and prey upon wild animals, and that they are therefore considered to be the main carriers of rabies.

The Southern portion of the Mandated Territory of South-West Africa settled by Europeans has apparently remained free from the disease, except for an unconfirmed case in the Grootfontein district where a European woman, having been bitten by a wild (grey) cat six weeks before, developed symptoms of hydrophobia and died.

#### NATIVE BELIEFS AND REMINISCENCES OF LOCAL INHABITANTS.

Fitzsimons (1919) makes the following observation when describing the spotted genet (*Genetta felina*): "The saliva of this animal apparently has some poisonous property, but this has not been satisfactorily demonstrated". Further on he says, "Several cases have been reported of men dying two or three weeks after being bitten by genets. In these instances it is stated, that after being severely bitten on the hand or arm by a genet the wound healed satisfactorily, but subsequently violent and sharp pains radiated up the arm from the site of the bite into the shoulder, followed later by symptoms, which seemed to resemble hydrophobia". This statement not only agrees closely with actual cases that have been observed and described in later years, but it is all the more significant that it was written at a time (1919) when hydrophobia was not thought to exist in South Africa.

Cluver (1927) in a report on the suspected cases of hydrophobia in human beings from 1916 to 1927, systematically investigated reports of madness in animals in the Vryburg and Mafeking districts. He remarks on the surprising general belief in these two districts amongst both natives and Europeans that a fatal madness follows the bite of a mad wild cat. The Genet cat being singled out as normally a shy animal and very seldom seen, but when mad it will approach homesteads and attack people. He further mentions, that tales relating to such cases go back twenty years.

Sergeant Roberts (1937) of the South African Police at Vryburg, a keen observer of wild life, informed me in a personal communication that as a boy about 35 years ago the old natives at Sterkstroom in the North Eastern Cape Province where he lived, always warned him that the bite of the Genet cat was fatal, but took effect only after six weeks, when the wounds had healed.

On his arrival in Vryburg in 1906 he heard of the same belief amongst natives, and during his thirty-one years as police officer, he heard and dealt with a number of deaths resulting from the bite of wild animals behaving very strangely.

Of some interest is a tale related to him of a family living near Maribogo. It was stated, that about 1885 three children were playing outside their house when one of them was attacked by a Tsipa (Genet cat), and that the child died a few weeks later.

## STUDY AND CONTROL OF THE VECTORS OF RABIES.

Sergeant Roberts feels convinced that on account of the numerous cases related to him from different sources, wild carnivora have been infected with rabies for very many years.

If the information obtained from these various sources is correct, one may assume that rabies existed in the small wild carnivora before the outbreak of 1893 at Port Elizabeth.

### BRIEF REVIEW OF LITERATURE DEALING WITH RABIES IN SOUTH AFRICA.

Cluver (1927) described all the suspected cases that had occurred in the Union since 1916, when the first case was discovered. All these cases were diagnosed clinically.

In all, ten cases were recorded from 1916 to 1927. In four of the cases the biting animal was a yellow mongoose (*Cynictis penicillata*). In four others the biting animal was a dog. In one, either a dog or a yellow mongoose appeared to have been responsible for the disease. In the tenth case the history implicated the spotted genet (*Genetta felina*).

These cases all occurred in the Northern part of the Union, in a triangular area formed by Bloemfontein in the South, Mafeking in the North and Ermelo in the North-East.

Mitchell (1929) commenting on the sporadic cases of suspected hydrophobia, stated that all the cases were investigated by the Public Health Department, but none of these cases was confirmed by laboratory examination, owing to unfortunate delay in submitting material.

The first cases, in which the diagnosis was confirmed, occurred on the 20th and 23rd November 1928. On November 17th, 1928, two boys, who had been bitten 19 days previously in an endeavour to catch what appeared to them to be a tame yellow mongoose on the farm Cyfergat 44, Wolmaransstad district, became ill and showed symptoms of hydrophobia. Brain material was submitted to both the Medical Research Institute, Johannesburg and the Veterinary Research Laboratories at Onderstepoort.

The diagnosis at both institutes was confirmed by demonstrating negri bodies and subinoculation into rabbits. Mitchell concluded his report with the remarks, that the long search resulted in establishing the fact, that the infection of rabies or hydrophobia existed in smouldering and enzootic form amongst, and was being perpetuated and spread by the wild fauna over a considerable area of the Union.

Du Toit (1929) in reviewing the rabies problem in South Africa described further cases of rabies in which the diagnosis was confirmed by laboratory methods. The first case in a yellow mongoose, caught on the farm Cyfergat, where the two boys referred to above were bitten in October 1928, was on the 1st April, 1929, and three others viz. in a dog, an ox, and a European child. The last was bitten by a genet cat.

Neitz and Marais (1932) described in detail the experiments conducted with material taken from the two boys at Cyfergat, and on material sent in from cases further outbreaks that had occurred up to that time. Some twenty-six outbreaks were tabulated by them, giving the distribution of the outbreaks and the known carriers.

In 1933 Neitz and Thomas tabulated the cases of rabies that had occurred during 1932, and drew attention to the spread of the disease.

### RABIES IN OTHER COUNTRIES.

In spite of the advances, that have been made in the study of rabies, the disease still exists in the majority of countries throughout the world. Australasia is the only continent that is entirely free from rabies.

*Europe.*

The disease is very prevalent in the Central and Eastern states of the Continent, while England, Belgium, Holland and the Scandinavian Peninsula are the only lands from which the disease has been eradicated.

Of the other countries France, Germany and Italy have the best control of the disease. In Germany only one case has occurred in a human being since 1930, while in France it was diagnosed in 143 dogs and 33 cats during 1937. The disease is worst in the South Eastern States of the Continent. The cases reported for 1937 vary from 256 in Greece, to 708 in Bulgaria. In Yugoslavia in 1936 a great increase in the disease occurred in the mountainous districts, where wolves played a great part as carriers. Over 27,000 cattle in the Province of Vardar were attacked by wolves, which it is thought numbered approximately 10,000. During the same year the disease was diagnosed in 904 dogs, 34 cats, 14 equines, 144 cattle, 50 sheep, 11 goats and 71 pigs. In the following year it was diagnosed in 1,110 dogs and cats, and in 738 other animals.

*United States of America.*

It is reported that rabies has increased in recent years in the Southern States and during the period 1929-1934, examination for rabies gave positive results in the brains of 4,256 animals in Alabama, 2,912 in Tennessee, 2,757 in Texas, 2,379 in Georgia, 1,097 in Mississippi and 496 in Florida. 86 Per cent. of the domestic animals concerned in the cases of rabies in human-beings were dogs, 6.3 per cent. cows, 4.8 per cent. cats, the rest being horses, rats, goats, hogs, rabbits, and monkeys.

It is further stated, that rabies is quite prevalent in 19 out of 53 states, and that Illinois has more rabies than any other state, only 9 states being free from the disease.

*Canada.*

From Canada it is reported that rabies is rare. In 1933 the disease was diagnosed in 7 dogs, 2 bovines and 3 sheep.

*South American States and West Indian Islands.*

In some of the South American States notably Brazil, Paraguay, British Guiana and others, and certain of the West Indian Islands, e.g. Trinidad and Tobago, the disease assumes quite a different aspect in that the vectors are species of vampire bats. The disease is known as "Mal de Caderas" in Paraguay, Bolivia and the Argentine, and as "Pests das Cadaras" in Brazil. In both the furious and quiet forms of the disease an early symptom is inco-ordination of movements, which led to the disease being confused with trypanosomiasis, and therefore called by the same name.

Here the outbreaks are marked by a disproportion between the small number of rabid dogs and the large number of cattle infected. In Trinidad alone during the years 1929, 1930 and 1931 the death rate averaged a thousand animals each year, and ninety per cent. of the animals affected were bovines. Only two cases were seen in dogs.

In Venezuela rabies in dogs is quite prevalent, but more so in foxes. It also occurs in other wild animals, such as the skunk. In the interior of the country, where the grey fox can be seen staring at one on every acre bordering the forests, they come when rabid into the dwelling-houses. During the day they are more dangerous, as they suddenly come round corners and bite young children. At night inhabitants sling their hammocks high to avoid these animals.

*Japan.*

Great progress has been made in Japan by the adoption of prophylactic vaccination measures. The incidence declined from 1,041 cases in 1918 to 60 in 1930.

## STUDY AND CONTROL OF THE VECTORS OF RABIES.

### *India.*

The disease has been known for many centuries, and its wide-spread nature is, owing to the religious views of the natives not to take life, resulting in numerous so-called pariah dogs prowling about the villages. The numerous anti-rabid clinics set up are indicative of the prevalence of the disease.

### *Malay States.*

Mitchell (1930) sums the position up as follows: "In the East, where artificial methods of sanitation are still very rudimentary, nature provides her own means of disposal of waste material by calling to her aid vultures, crows and pariah dogs, and so long as there is an available food-supply pariah dogs will maintain their numbers. The Burman, on account of his religious views, will not willingly take life in any form, and until the rabid animal becomes a menace to human life, little action is taken."

Under these conditions it is only natural that rabies infection is widely disseminated. A small army of suspects is daily treated, at the Pasteur Institute in Rangoon, with a carbolized virus with very good results.

### *Ceylon.*

The disease is prevalent throughout the island, and in 1934 out of 272 suspected cases in dogs, 132 proved positive and in 1936, 253 cases were positive.

### *Dutch and French India.*

The position is the same here as in the Malay States.

### *Hong Kong.*

The main duty of the Veterinary Police consists of enforcing control measures against rabies.

### *Palestine.*

The disease is enzootic in Palestine, and during 1937, 122 cases were reported positive out of 587 suspected cases, and during the same year 19,930 stray dogs were destroyed.

*In Iraq, Persia, etc.,* the disease is very widely spread as no control measures are adopted at all.

*The Pacific Islands* are considered to be free from the disease.

### *African Territories.*

Rabies is wide-spread on the African Continent, and is more prevalent in the Northern than in the Equatorial and Southern Territories. In North Africa the disease has been known for centuries, and is enzootic. In Morocco, Algiers, Tunis, and Egypt the disease is widely distributed and more than a hundred cases from each country are reported every year. The disease is chiefly caused by ownerless dogs, which stray in the Arab villages, and in spite of drastic measures it seems to be on the increase.

*In Central Africa* the disease, although wide-spread, is not very prevalent. In the Congo, Cameroons, Sudan, Nigeria, Ivory and Gold Coast, the disease is enzootic appearing as epizootics which die out, and is known as "Ouloufato", or mad-dog disease. Dogs are the exclusive carriers of the disease, and, although the paralytic form predominates, the virus is the same as that of classical rabies. It is further reported that human-beings very seldom contract the disease, although they are frequently bitten. In British Sudan and Somaliland, Abyssinia, and Eritrea the disease is very prevalent as the result of little control work.

In Kenya the disease was first diagnosed in 1929, and was found to be similar to classical rabies. The jackal is the only important host apart from the dog. In 1935, the disease was diagnosed in seven dogs, fourteen jackals, and one cow.



In Tanganyika the disease has not been diagnosed with certainty, although several suspected cases have been reported of which one was in a human-being.

In 1916 a suspected case occurred in Nyasaland, and in 1924 it was thought that the disease did not exist in the territory, but in 1926 its existence was definitely established.

In Northern Rhodesia the incidence has increased since 1927, and in 1931 one of the seventeen positive cases, that were reported, originated from a jackal. The infection has further been found in cats and monkeys, but has not been noticed in *Viverridae*.

In the Bechuanaland Protectorate a case was diagnosed in a native child in 1936, and as a prophylactic measure dog-free belts were established and some 2,000 dogs were destroyed.

Southern Rhodesia has been free from the disease since the epizootic which terminated in 1914 until 1938 when a case occurred again in a dog. The outbreak was successfully checked.

In South West Africa the disease has definitely been established in the Okavango area, where it seems to be enzootic.

#### *Madagascar.*

In Madagascar rabies is prevalent throughout the island. The dogs, which run all over the island in famished packs congregating around slaughter-houses, fumigators and meat factories, are the main carriers of the disease. In spite of twenty-five years of control, the disease runs yearly through the island with exceptional severity amongst natives, owing to their lack of hygienic measures.

## **RABIES IN SOUTH AFRICA.**

The incidence of rabies in the Union of South Africa may be discussed under the following headings:—

- (1) The distribution of the disease.
- (2) The occurrence of the disease in definite foci or centres.
- (3) The origin of the disease in fresh outbreaks.
- (4) The spread of the disease.
- (5) The possibility of a seasonal influence on the occurrence of rabies.
- (6) The epizootics of rabies that have occurred during the period November, 1928 to August, 1929.

### (1) THE DISTRIBUTION OF RABIES.

The distribution of rabies in the Union may be divided according to the incidence rate, into a Central area where the disease is very prevalent, and adjoining this, a North-Eastern and a Southern area where only a few isolated outbreaks have occurred, the Peninsular area in the extreme South of the sub-continent, and the extreme Western area of Griqualand West.

#### *The Central Area.*

This area may briefly be described as the area bounded on the West by the Vryburg, Christiana, Boshof, Jacobsdal, Fauresmith and Philippolis districts, on the South and East by the districts of

Trompsburg, Edenburg, Bloemfontein, Thaba'Nchu, Senekal, Kroonstad and Klerksdorp, and on the North by the Ventersburg, Lichtenburg and Mafeking districts.

The sand-veld, of the Eastern portions of Boshof and Hoopstad districts in the Orange Free State and the Southern portion of Wolmaransstad district in the Transvaal, may be regarded as the centre or nucleus of the area where the disease is most prevalent. The incidence of the disease in this sand-veld area corresponds very closely with the distribution of *Cynictis penicillata*. A study of the relevant map (No. 1) clearly indicates this point.

#### *The North-Eastern Area.*

This area may be described as the one adjoining the Central area on the North-Eastern side by the districts of Heilbron, Potchefstroom, and Krugersdorp, and extending eastwards over the Brakpan, Bethal, Middelburg, Carolina, Standerton, and Frankfort districts.

#### *The Southern Area.*

Apart from one centre on four adjoining farms with Swartkops as the nucleus in the Middelburg (Cape) district, the infection occurs as isolated spots over the districts of Cradock, Middelburg, Maraisburg, Hanover, De Aar, Britstown, and Carnarvon.

#### *The Peninsular Area.*

This is a small isolated area confined to the Cape Peninsula. Two cases, both in dogs, were discovered within a period of two months. There is unfortunately no history associated with these two outbreaks to indicate the source of the infection. Its origin, therefore, remains obscure, especially in view of the great distance from known existing infection in wild animals. It is thought that *Genetta* may be responsible for these outbreaks as genets abound on the slopes of Table Mountain.

#### *The Extreme Western Area of Griqualand West.*

This area has recently become infected. An isolated case occurred on 18th August, 1939, in a Genet on the farm Selfdink in the Hay district.

The districts adjoining, and those in between, the areas described above must be regarded as suspected areas.

The incidence of the disease follows the distribution of *Cynictis penicillata* very closely. This is clearly shown by the fact that the disease has never been found in the lime slopes of the Gaap Mountains, a range running through Taungs, Barkly West and Herbert, west of and immediately adjoining the sand-veld. The sharp decline in both the incidence rate of the diseases and the population density of *Cynictis* is in marked contrast to the gradual decrease to the eastward of the Central area of both the incidence rate and the population density of *Cynictis*.

## (2) THE OCCURRENCE OF THE DISEASE IN CENTRES OR FOCI.

As has been pointed out before, Snyman and Thomas consider that although the disease is widespread over a large part of the country, it is restricted to more or less well defined centres over the greater part of that area.

On a large scale map, on which the boundaries of farms are marked, this becomes very evident. The description of a few of these centres will illustrate this.

(i) *The Dealesville Centre.*

The infected mongooses discovered near Dealesville were all found on the Southern portion of the Commonage. At the two adjoining farms of Doornrandjies and Kromspruit, although both outbreaks occurred in oxen, there is, nevertheless, a history of a rabid mongoose in each of the two cases, and the paddocks in which these were found both adjoin that portion of the Dealesville commonage on which the infected viverrids were found. The infection had been known to exist in that comparatively small area for five years without any further spread having been reported.

(ii) *The Groenplaas and Resida Centres.*

The first in Frankfort, and the second in Senekal district, are two very good examples of isolated centres of smouldering rabies infection. In both instances the nearest known infection was some 35-40 miles distant, and both centres are situated in areas where the yellow mongoose is not very abundant.

In the first mentioned centre a low ridge, on which isolated colonies of *Cynictis* are found, passes over both the farms Groenplaas and Boomplaas. It is probable that the infection may exist on the ridge of hills only, as the valleys on both sides of the ridge consist mainly of cultivated lands, where *Cynictis*, if present, would appear in restricted numbers. In view of the fact that no cases, except the one in an ox, were reported subsequent to the death of a European girl, in spite of the sensation created by her death from Hydrophobia following the bite of a *Cynictis*, it may safely be concluded that the disease may smoulder under such circumstances for a long time without being discovered.

(iii) *The Mara Centre, Bloemfontein District.*

From the history obtained on the first case of rabies in this centre it is obvious that the disease has been smouldering there for a number of years. A very careful survey of the viverrid population was made, when the meercat eradication operations (to be described later) were undertaken. It was found, that the two vleis, which pass over the area and which eventually join, allowed the meercats, which abounded there, to come in close association over the two farms on which the outbreaks occurred. See Sketch Map No. 2.

(iv) *The Trompsburg Focus.*

Map No. 6. The Trompsburg Commonage is divided into three grazing camps, known as the cow, calf, and refuse-camps, which are separated from one another by wire fences only. A spruit, which is dry for the greater part of the year, runs through all three camps. The colonies of the yellow mongoose are mainly along the valley in which the spruit runs, except that portion of it which runs through the calf-camp. This interruption of the continuity of the occupation of the valley by the yellow mongoose is caused by the abattoirs, in the vicinity of which no colonies occur. Between the cow-camp and the calf-camp, is a large low-lying plain in which the yellow mongoose, although it has been seen there, has established no known colonies. The plain and the abattoirs on one side and the village on the other side form a barrier between the cow and calf camps which the yellow mongoose very seldom traverses.

From the places marked on the map, where the diseased mongooses have been found, it is obvious that they have all originated from the cow-camp adjoining the town on the South. It is hardly conceivable that mad mongooses would wander through the town and be found on the other side. One must, therefore, accept the probability that the diseased meercats have not come from either the calf or the refuse-camp. Besides both camps are frequented by herd-boys and infected mongoose would have come to their notice in the North, just as they have in the South. It is therefore, accepted, that the infection is confined to the area immediately to the South of the town.

From the above it is obvious that rabies in the lesser carnivora may smoulder on a comparatively small area, three miles square for five years before spreading to adjoining areas, and periods as long as 19 months have elapsed without another case occurring.

(v) *The Swartkoppies focus, Middelburg (Cape).*

In this instance four adjoining farms were infected, and in view of the isolated number of outbreaks in the Southern area, one may conclude that there was a common source of infection. The disease was diagnosed in three different species of *Viverrids*.

(vi) *The Centres of Rabies Infection in the Vryburg District.*

In this district four centres of infection exist. The first with Middelbult as centre, consists of five farms, which are adjoining and two farms a short distance away. The disease occurred in the following order, a suspected case in an ox, at England in 1926, Zaaiplaas, 1930; Middelbult, 1932; Crondale, 1933; Caledon, 1934; Maizefield, 1936, and Skietpan in 1938. The order in which the outbreaks occurred shows the slow advancing character of the disease. It is difficult to understand that the disease should spread from England, assuming that this farm forms the origin of the infection, to Zaaiplaas and not to Maizefield. Similarly, that it should skip Skietpan to occur at Caledon and to appear five years later only on Skietpan.

The second centre is that formed with Lorenzo, the oldest known infection. In this case there are four farms adjoining in which the infection has been smouldering from 1926 to 1937, a period of almost eleven years, and in the case of the two adjoining farms, Massouwskop and Kromspruit, for a period of six years.

The third centre, consisting of the two farms, Vryburg Commonage and Boston, may be considered as a separate infection. It is, however, possible that it is connected with Kromspruit.

The fourth centre consists of two adjoining farms forty miles away from the nearest infected area of Vryburg town.

(vii) *Hoopstad District.*

Even in this district, where the disease is widespread, it is possible to group infected farms together, so that definite centres of infection are formed. Two such centres, viz., Texrede and Heestersrust, exist in that area. In the former case where four farms are adjoining, the infection was discovered on three of the four farms in the same year, and six years later only on the fourth farm, Rechtvaardig.

In the case of the other centre, although the four farms which are infected are not adjoining, the area in which they are situated forms a triangle with sides approximately five miles long.

(viii) *Isolated Centres.*

It has been pointed out in the case of the infection on the Trompsburg Commonage, that the disease may exist in a comparatively small area. Further such cases may be mentioned, where infected meercats at different intervals have been found on the same farm and even in the same locality on the farm.

On the Edenburg Town Commonage (see Map No. 5) infected *Cynictis* were found in April and August, 1933, at the points marked X on the sketch map. In June, 1939, a further infected *Cynictis* was found on the same part of the Commonage at the point marked XI.

At the farm Sunnyside, near Bloemfontein, outbreaks of rabies occurred on the 4th and 21st of May and again in July of the same year. All these outbreaks occurred in an area with a radius of less than half a mile. (See Sketch Map No. 4.)

At the farm Philip, in Hoopstad District, an outbreak of rabies occurred in November, 1937, in an ox and on the 23rd of May the following year a rabid *Cynictis* was found in the same camp, where the ox had been grazing. More such cases can be quoted, e.g., Beestekraal in Hoopstad District, of the discovery of the disease in comparatively small areas of approximately 1,000 morgen in extent. These cases further support the view that the disease occurs in restricted areas.

## (3) THE ORIGIN OF THE INFECTION IN FRESH OUTBREAKS.

In nearly every fresh outbreak of the disease the same question is raised: What is the origin of the infection? In the absence of any direct evidence, the only reply that can be given is that the disease has always been there, but has remained undiscovered. This reply is based on the presumption, as has been shown above, that rabies may smoulder in the lesser carnivora in a comparatively small area for periods up to eleven years, without being discovered. Most of these isolated "fresh" outbreaks should probably, therefore, not be considered as newly-started foci, but rather as old-established infections that are being discovered.

There are many outbreaks where a single infected animal was found, and without any attempt at eradication, the disease has presumably disappeared. Areas where such sporadic outbreaks have occurred should, therefore, be regarded as suspect until they can be proved otherwise. There are many instances where the disease has appeared recurrently after periods of up to eight years, e.g., Trompsburg Commonage, the farm England in the Vryburg District, Cyfergat in the Wolmaransstad District where the first case that was definitely diagnosed as rabies came from. The first case was diagnosed in two European boys bitten by a *Cynictis* in 1928, and only eight years later another case was recorded on the same farm in a dog.

One often hears it related when dealing with sporadic outbreaks, that animals behaving very strangely were seen there twenty or more years ago. For instance at Ventersvlei, Bloemfontein District, an obviously rabid wild-cat was said to have been discovered near the homestead in broad daylight some twenty years ago. This story is all the more interesting as the nearest known infection is some 30 miles away.

## (4) THE SPREAD OF THE DISEASE.

It has often been said that migratory animals will spread an infectious disease as fast and as far as they themselves can travel. Unfortunately very little is known about the migratory habits, if any, of the principal carriers, *Cynictis* and other species of Viverrids. The possibility, that such animals may be removed over long distances as pets, should not be overlooked. A pet *Suricata*, which developed rabies in Carnarvon in 1930, might easily have been the cause of an outbreak in a different part of the country. Similarly, the two pet *Suricates*, to be described later, that were moved to Natal, where *Suricates* do not occur, might also have been the cause of an outbreak.

Several cases are recorded where domestic animals, fortunately cattle only, have been responsible for fresh outbreaks. In the case of Nieuwebaby, Boshof District, the ox concerned was removed from Middelpunt, a farm on which a suspected case of rabies occurred in a domestic cat.

In the outbreak in a donkey on the farm Waagpunt, Boshof District, the animal was removed from the farm Lemoenplaas some 10 miles away, a week before the onset of symptoms. A similar

movement of an infected ox took place during the outbreak at Kommandodrift, Wolmaransstad District. The outbreak reported at Goedgedacht, Ventersburg District, actually occurred in an ox on an adjoining farm where the oxen had been grazing.

Owing to the long period of incubation in rabies, in some cases a period of six months or more, the possibility of spreading the disease by movement of domestic animals is very real and may explain why the disease may at times take unexpected long jumps. However, apart from the few cases mentioned where animals were removed during the incubation period of the disease, it has been found that the disease spreads relatively slowly to adjoining areas by means of wild carriers.

#### (5) THE PROBABILITY OF A SEASONAL INFLUENCE ON THE OCCURRENCE OF RABIES.

Thomas and Neitz (1933) at the termination of the great drought of that year, speculated on the influence the copious rains and floods, that followed the drought, would have on the incidence of rabies. It was thought, that as a result of the abnormal floods a large proportion of small wild animals would be drowned and so the incidence of rabies be lessened.

The copious rains started in the middle of November only, and the anticipated decline in the incidence rate occurred in September of that year and, therefore, was not related to the rain.

Schumann and Thompson (1934) in a study on South African Rainfall, Secular Variations and Agricultural Aspects, divided the Union of South Africa into 32 districts, on a basis of the distribution of the average monthly rainfall, as well as on the topography of the country.

In their tables the rainfall is indicated as the percentage of the mean rainfall based on data (in the case of districts No. 28 and No. 32) from 1904 to 1933.

From the boundaries of the rainfall districts defined by Schumann and Thompson it was found that the Central Rabies Area as described very nearly coincides with rainfall district No. 30, and the greater portion of No. 28. The small areas of the other districts that are not included in the Central Rabies Areas show only a few isolated outbreaks. The rainfall for the nearest station was obtained for record purposes. The monthly rainfall for the Central Rabies Area was obtained from the Meteorological Office for the years 1929 to 1938. The data of 22 stations were used in compiling the actual monthly rainfall in Graph 1.

Graph No. 1 shows for the Central Rabies Area: -

- (a) The average monthly rainfall.
- (b) The actual monthly precipitation.
- (c) The monthly number of outbreaks of rabies indicated in Table I.

STUDY AND CONTROL OF THE VECTORS OF RABIES.

TABLE I.

*Summary of the Incidence of Rabies. 1929-August 1939.*

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1929.....	1	1	—	2	2	—	3	2	1	—	1	—	13
1930.....	1	2	2	—	—	—	—	—	3	2	—	—	10
1931.....	1	—	—	1	1	1	—	—	1	—	—	—	5
1932.....	—	—	—	1	2	4	2	2	2	—	—	3	18
1933.....	—	3	2	3	1	4	5	6	—	1	2	—	27
1934.....	2	—	1	—	—	1	1	—	—	1	—	—	6
1935.....	1	—	—	2	1	—	2	3	3	2	2	4	20
1936.....	2	8	1	2	4	3	2	4	5	—	—	—	31
1937.....	1	—	1	—	1	—	—	2	1	—	3	4	13
1938.....	1	—	2	2	4	2	2	5	7	6	—	4	35
1939.....	3	2	1	—	5	2	4	5	—	—	—	—	18
TOTAL.....	13	15	10	13	21	17	21	29	23	14	9	15	179

*The Periods during which the Incidence Rate of Rabies was Comparatively High.*

Table II shows the periods in which the incidence rate of rabies was comparatively high.

For the sake of comparing the periods contained in Table II with the seasonal precipitation, the periods have been divided according to the rainfall, into summer for the months November to March; early winter May and June; mid-winter July and August; late winter September and October. The month of April which marks the end of the rainy season and the beginning of winter is given as a separate period.

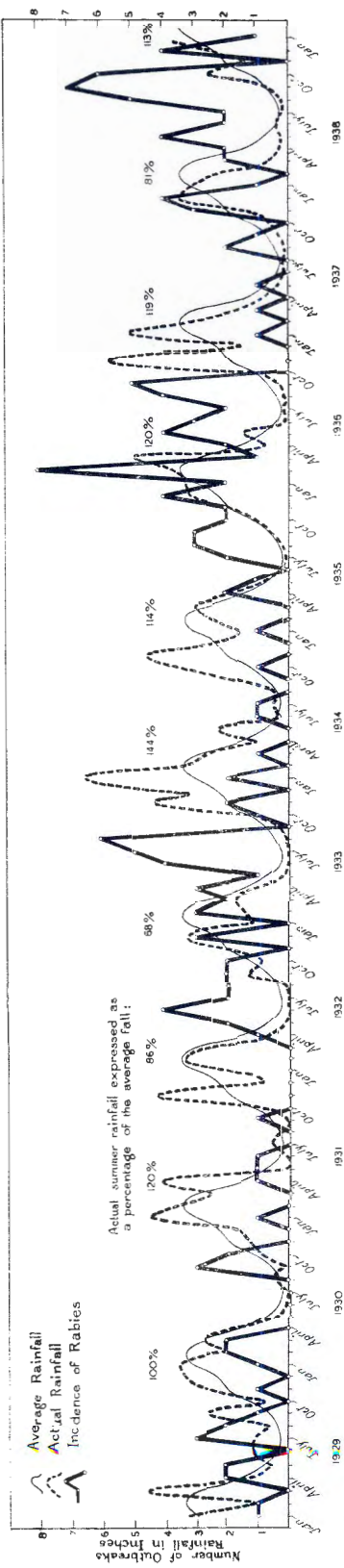
TABLE II.

*The months in which the Incidence Rate of Rabies was Comparatively High.*

Summer.	April.	Early Winter.	Mid Winter.	Late Winter.
December, 1932.....	1933	June, 1932....	July, 1929.....	September, 1930.
February, 1933.....		June, 1933....	July, 1933.....	September, 1935.
December, 1935.....		May, 1936....	August, 1933..	September, 1936.
February, 1936.....		May, 1938....	August, 1935..	September, 1938.
November, 1937.....			August, 1936..	October, 1938.
December, 1937.....			August, 1938..	
December, 1938.....			August, 1939..	
TOTAL.....		7 times	Once	4 times
				5 times



GRAPH No. 1.



In comparing the data in Table II with the data in the graph, the following points are rather striking:—

(1) *Early Winter.*

It will be noticed that an increase in the incidence rate of rabies occurred four times during early winter. In three out of the four cases the rainfall for the previous late summer months was far below normal, May, 1936, being the exception.

(2) *Midwinter.*

The incidence rate of rabies increased seven times during midwinter.

(3) *Late Winter.*

The increases in the incidence rate of the disease occurred in each case before any rains had fallen.

(4) *April.*

The only time when an increase occurred during the month of April was in 1933, when an abnormally low rainfall was recorded for the previous summer.

Thus to summarise, the incidence rate of rabies was comparatively high sixteen times when the precipitation was below normal for the previous late summer months or before any rain had fallen. In the 17th case the rainfall for the previous summer was 20 per cent. above normal.

The highest increase in the incidence rate occurred during 1933, late 1936, and 1938, at times when the veld was comparatively bare, especially in 1933 and 1938 when the previous summer rainfall was respectively 32 and 19 per cent. below normal.

(5) *Summer Periods.*

An increase in the incidence rate of rabies occurred seven times during the summer months. On these occasions the climatic conditions were as follows:—

*December, 1932.*—A little rain fell in the previous September but October and November being dry, the little rain in September had no influence on the veld.

*February, 1933.*—The increase in the incidence rate of rabies during the summer coincided with one of the worst droughts known in the country.

*December, 1935.*—The rainfall for the month was above the normal as well as that for the previous two months. So that the increase occurred at a time when the vegetation was well grown.

*February, 1936.*—The same applies in this case as in the previous one.

## STUDY AND CONTROL OF THE VECTORS OF RABIES.

*November, 1937.*—The preceding two months were dry, when rain should have fallen normally. The veld as can be expected was bare and dry

*December, 1937.*—The rainfall for the previous two months was far below normal, and that for the same month above normal. But at the time when the incidence rate of the disease reached its peak, the veld was still bare, as the copious rains resulted in dense vegetation only after three weeks.

*December, 1938.*—Although some rain had fallen in October a very severe frost occurred during the middle of November, and December being still dry the veld was exceedingly bare.

Five out of the seven periods described above may be described as being dry or very dry, resulting in very poor vegetation, and in two of these months severe droughts were recorded.

In the remaining two months, viz. December, 1935, and February, 1936, copious rains had fallen during the preceding month, so that the veld was practically overgrown and the vegetation tall.

It will be seen from the above that the incidence rate of rabies tends to increase during the winter, and that when increases are recorded in summer they coincide with conditions of veld in which the vegetation is very short or almost absent.

On twenty-one occasions out of twenty-four, when a comparatively high incidence rate of rabies was recorded, it coincided with periods when the vegetation was short or no vegetation existed, and on three occasions only occurred when the grass was tall and the veld overgrown.

From the above it may be concluded that drought or scarcity of vegetation to some extent at least influences the number of outbreaks of rabies recorded. This would not necessarily mean that epizootics occur during such periods. The larger number of outbreaks recorded during such periods is probably due to the fact that meercats traverse larger areas searching for food, and when they become rabid they are easily seen, or the scanty vegetation allows such animals to wander further afield than when the grass is high and tall. It is therefore concluded that the increase in the incidence rate of rabies during such periods is only apparent and does not constitute an actual increase in the number of cases that occur normally.

### (6) EPIZOOTICS OF RABIES.

Graph 1 indicates that the outbreaks of rabies occur in waves or epizootics. Three such epizootics are evident, viz. one during the period May, 1932, to August, 1933; the second from August, 1935, to September, 1936, and the last one during the period November, 1937, to December, 1938.

#### *The First Epizootic.*

The whole of the period, during which this epizootic occurred, coincided with a period of severe drought when vegetation was very scanty. The climax was reached during the last three months of the period when it terminated very suddenly.

*The Second Epizootic.*

In contrast to the former outbreak there is a gradual rise in the curve until a peak is reached, but although there is a sudden drop from the peak, the curve is still regular until the final peak is reached, when there is again a sudden drop. This epizootic coincided with a comparatively wet period, when the rainfall was from 14 to 20 per cent. more than the average, resulting in abundance of vegetation and food for all three varieties of meercats.

*The Third Epizootic.*

Although there is some fluctuation in the initial stage, yet there is a gradual rise in the curve which, in contrast to the two former, shows a sharp but well defined termination. The epizootic started after a summer marked with copious rains in the first part of the season, but which ended with a fall below the average and continued through an exceedingly dry summer.

In all three instances the epizootic terminated prior to any rains having fallen, which clearly indicates that the termination in each case cannot be described to drowning of the meercats, or overgrown vegetation obscuring rabid animals.

If all three cases are regarded as definite epizootics then they are very wide spread over the whole of the infected areas of the Union, occurring in each instance over the Western O.F.S., Western Transvaal, and the Eastern portion of Bechuanaland.

Owing to the widely distributed nature of the epizootics occurring over such a large area at the same time it is difficult to conceive that they can be regarded as true epizootics, considering that the disease started from one centre and swept over the country, like the outbreak of rabies that occurred at Port Elizabeth in 1893. The epizootics must rather be regarded in the light of some factor or factors, common to the whole of the area, causing a "flare up" of the disease in the various centres of infection, where the disease was smouldering.

The fact that all three epizootics terminated equally suddenly may be regarded as proof that the common factor or factors ceased to act over the whole of the area affected.

Beyond speculation, it is impossible at this stage, with our meagre knowledge, to state what factor or factors influenced these epizootics. It is only with intensive study of the life-history and migratory habits of the vectors of rabies that knowledge concerning the epizootology of the disease would be gained.

## (7) INCIDENCE OF RABIES IN DOMESTIC ANIMALS.

Theiler (1934) stated that biological and histo-pathological investigations proved that the disease encountered in South Africa was identical with the rabies of Europe.

## STUDY AND CONTROL OF THE VECTORS OF RABIES.

It is peculiar, therefore, that the dog which plays the most important rôle in the epizootology of the disease in Europe, should only play a secondary rôle in this country. Of the twenty-one cases in dogs, only two can be accounted for by the bites of rabid dogs, and thrice only did it cause rabies in other animals. See Table 4.

Several explanations have been suggested for this, amongst which the following may be regarded as contributory factors.

(i) The dog population in this country is comparatively small especially in the Orange Free State, owing to the heavy tax of ten shillings per head and the severity with which the tax is imposed. During the later half of each financial year, all policemen in the Province have a standing order, by Administrator's Ordinance, to destroy on sight any taxable dogs not carrying the metal disc showing owner's payment for the necessary dog licence. Further the whole of the rabies-infected area falls within the sheep-farming area of the country. Farmers here are loth to keep too many dogs and natives are practically forbidden to keep dogs, owing to the fear of marauding dogs chasing and killing sheep. Sheep-owners are continually on the look out for dogs trespassing on their properties, and any dog straying in the veld is shot and nothing said about it.

In one instance the author was told by a farmer that in six months he had destroyed fourteen dogs trespassing on his property.

In all four of the Provinces of the Union the Ordinances, relating to the keeping of dogs and the dog-tax, authorize the owner or occupier of any land on which stock is kept to destroy any dog found trespassing thereon not under the control or custody of any person.

(ii) The general fear of mad dogs causes the majority of owners to destroy their pets on the slightest suspicion of madness. Such drastic steps are taken easily as the majority of dogs have very little more than sentimental value, and another mongrel is easily obtained to replace the one that has been destroyed.

It is realised, in view of rabies having been spread by dogs to a considerable extent on a previous occasion in South Africa (Port Elizabeth 1893), that the peculiarity of the disease is not entirely due to the above, but that the explanations given must only be regarded as probable contributory factors, and that the peculiarity is similar in nature to that of rabies in the vampire bat of Trinidad and certain South American States, and "Oulou-fato" of French West Africa and the Congo.

(iii) As regards the rôle the other domestic animals play, very little need be said, except that the rabid ox is always a potential source of danger to human-beings. The practice in this country amongst farmers to diagnose any obscure disease as gallsickness and to dose such animals by pulling out the tongue exposes many to the dangers of rabies. In nearly all cases where the animal affected was a bovine, preventive inoculation had to be resorted to, and in one case as many as twenty natives had to be treated. There is one fatal case of a farmer ascribed to this practice.

## THE VECTORS OF RABIES IN SOUTH AFRICA.

Du Toit (1936) summarizes the outbreaks of rabies in the Union according to the species of animals in which the disease had been diagnosed.

In 1937 the author, in a discussion on the epizootology of rabies in South Africa, pointed out that taking into account the many outbreaks of rabies in cattle associated with a history of a mad mongoose, and the number of human-being cases in which the vector is definitely known to be *Cynictis*, together with the number of cases of rabies diagnosed in the *Cynictis* itself, it was obvious this species of animal is by far the most important carrier.

Table 3 gives a summary of the incidence of rabies in the various species of animals in which it has been diagnosed by laboratory methods. Some 20 cases in human-beings and 24 in animals have been added in which a laboratory examination was not made, but the history and clinical symptoms were such that rabies could not be excluded. These cases are bracketed in each instance. During 1937 the author dealt with 34 suspected outbreaks of rabies in the Orange Free State. In these 34 outbreaks, material for laboratory examination was not available in ten instances owing to the animals concerned having been shot through the head, or the material being too decomposed to be of any diagnostic value. Of the remaining 24 cases in which a clinical diagnosis of rabies was made, in two instances only was the diagnosis not confirmed. The inclusion of the cases of rabies, which were not confirmed in Table 3 would therefore not materially affect the data.

TABLE 3.

*The Incidence of Rabies in the Various Species of Animals.*

Species of Animals.	PROVINCE.				
	O.F.S.	Bechuana-land.	Cape.	Trans-vaal.	Total.
Man.....	6 + (11)	1 + (1)	4 + (2)	6 + (6)	17 + (20)
<i>Cynictis penicillata</i> .....	44 + (6)	4	1 + (3)	11 + (3)	60 + (12)
<i>Suricata suricatta</i> .....	1	—	2	—	3
<i>Myonax pulverulentus</i> .....	—	—	1	—	1
<i>Genetta felina</i> .....	1	6 + (1)	1	—	8 + (1)
<i>Felis</i> spp.....	2	—	1	—	3
<i>Geosciurus capensis</i> .....	1	2	—	—	3
<i>Ictonyx orangiae</i> .....	1	—	—	—	1
<i>Cynalopex chama</i> .....	1	—	—	—	1
Dog.....	12 + (2)	4	2	3	21 + (2)
Cat.....	5 + (2)	5	—	4	14 + (2)
Cattle.....	23 + (6)	6 + (2)	—	18	47 + (8)
Sheep.....	3	—	—	—	3
Pig.....	2	—	—	1 + (1)	3 + (1)
Equine.....	1	1	—	4	6
TOTAL.....	103 + (27)	29 + (4)	12 + (5)	47 + (10)	191 + (46)



STUDY AND CONTROL OF THE VECTORS OF RABIES.

TABLE 4.  
The known Vectors implicated.

Species of Animal.	Of Man.	Of Dog.	Of Cat.	Of Cattle.	Of Pig.
<i>Cynictis penicillata</i> .....	21	3	—	5	—
<i>Genetta felina</i> .....	3	1	1	—	—
<i>Felis</i> spp.....	2	—	—	—	—
Dog.....	4	2	1	1	1
Cat.....	2	—	—	—	—
Ox.....	1	—	—	—	—
<i>Geosciurus capensis</i> .....	1	—	—	—	—
DOUBTFUL.....	3	—	—	—	—
TOTAL.....	37	6	2	6	1

(a) WILD ANIMALS.

The wild animals which so far have been proved to carry and transmit rabies are the following in order of their relative importance:—

1. *Cynictis penicillata*.
2. *Genetta felina*.
3. *Felis ocreata* and *Felis negripes*.
4. *Suricata suricatta*.
5. *Geosciurus capensis*.
6. *Myonax pulverulentus*.
7. *Ictonyx orangiae*.
8. *Cynalopex chama*.

In addition to the several species of animals named above, cases of rabies in the jackal and hyena have been reported from the neighbouring territories of Rhodesia and Angola. The other species of carnivora such as the other two species of jackal, the Cape Hunting Dog, the Aardwolf, etc., in fact all of our numerous species of wild carnivora, must be regarded as potential carriers of rabies.

(1) *Cynictis penicillata*. (Illustration 3.)

It has already been shown, that the species most commonly concerned with rabies transmission is *Cynictis penicillata*. This animal has been responsible for the death of some 21 human-beings and five head of cattle, besides causing some 80 known outbreaks of rabies. That the disease is more prevalent in this animal, is not to be ascribed to any greater susceptibility to the virus of rabies, nor does the animal become any more ferocious when rabid than other species of carnivora. The reason is rather to be found in the fact that it is very abundant, living in small colonies near to one another, thus increasing the chances of contact for transmission much more than in the other animals, which are comparatively less abundant, and with a more solitary mode of living.

STUDY SKINS FROM THE ZOOLOGICAL SURVEY COLLECTION.

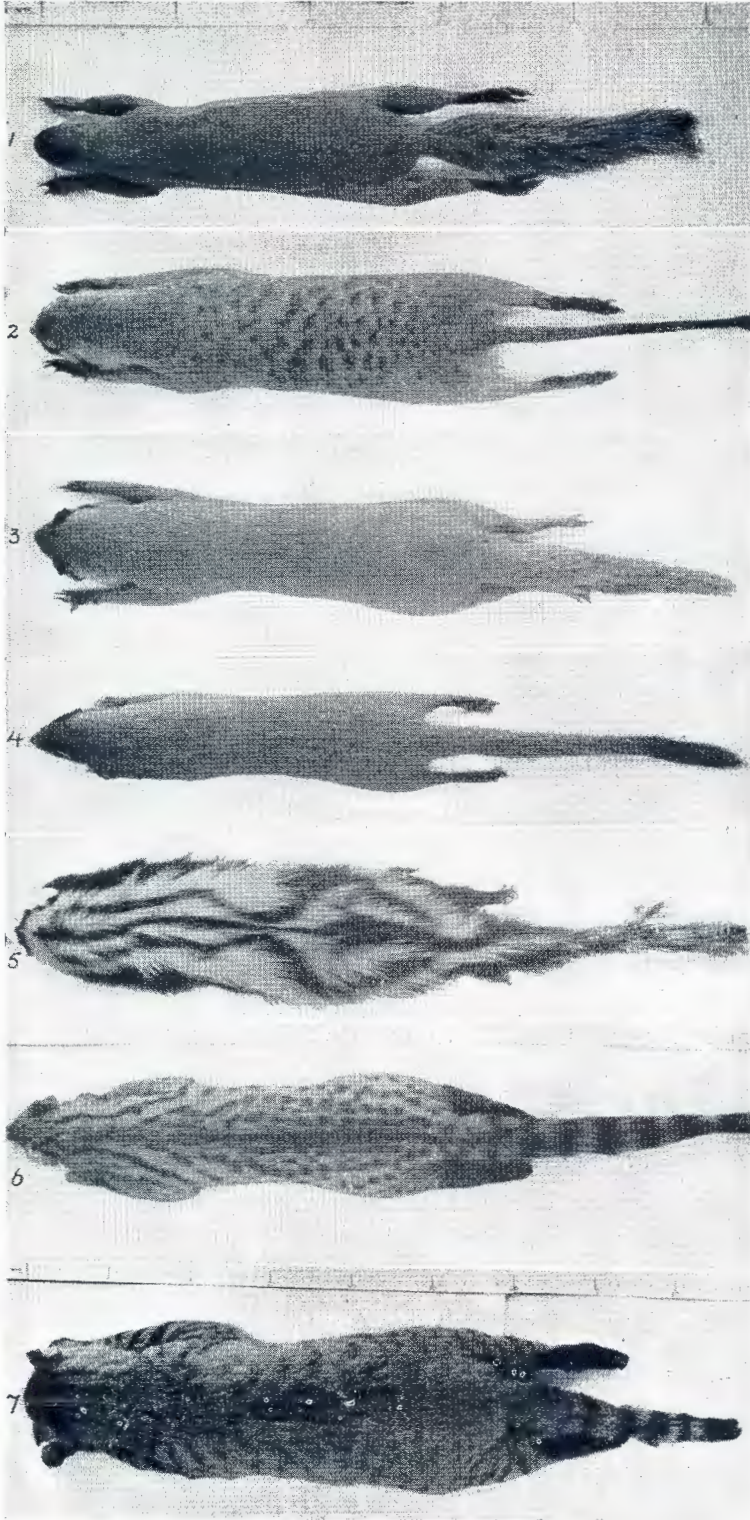


Illustration 1.—*Geosciurus capensis capensis* (Kerr). Ground squirrel.  
 Illustration 2.—*Suricata suricatta hamiltonis* (Thos. and Shw.). Suricate.  
 Illustration 3.—*Cynictis penicillata ogilbyi* (A. Smith). Yellow mongoose.  
 Illustration 4.—*Myenax canni canni* (A. Smith). Small grey mongoose.  
 Illustration 5.—*Ictonyx striatus striatus* (Parr). Pole cat, skunk.  
 Illustration 6.—*Genetta felina felina* (Thunberg). Spotted genet.  
 Illustration 7.—*Felis ocreata caffra* (Desma and Rest). Wild cat.



A very large proportion of the cases reported in human-beings are children, who through ignorance and their fondness for pets, are bitten in their endeavours to catch what appears to them to be a tame meercat, but which is actually rabid.

2. *Genetta felina*. (Illustration 6.)

It is interesting to note that the greater number of cases of rabies reported in this species of animal were in the Bechuanaland area, i.e., Vryburg and Mafeking Districts, where this animal also has been suspected for years by the natives as the cause of a fatal disease.

If one takes into consideration that the spotted genet is nocturnal and solitary in its habits then the few cases on record, especially those reported from the Bechuanaland area where it is probably more prevalent than in areas affording less shelter, one may assume that the disease is equally as prevalent in this animal as in the yellow mongoose.

3. *Felis spp.* (Illustration 7.)

Although this animal has a wide distribution over the whole of South Africa, it occurs only in isolated families. The few cases of rabies reported in this animal are therefore commensurable with the smaller chances of contact with this species of animal.

4. *Suricata suricatta*. (Illustration 2.)

The few cases reported in this species probably do not reflect the true state of affairs, if one takes into consideration its wide distribution, gregarious habits, and its close association with *Cynictis penicillata*, often occupying the same burrows. Possibly the fact that these animals are more inclined to wander over large areas in troops may have something to do with this.

5. *Geosciurus capensis*. (Illustration 1.)

While this animal is not a carnivore but a rodent, living in close association with *Cynictis*, cases of rabies in it could be expected. In fact it is surprising more have not been observed. In one case only there is evidence of its having caused the death of a child.

6. *Myonax pulverulentus*. (Illustration 4.)

This animal, being limited in its distribution and occurring in an area where rabies is not very prevalent, does not play a major rôle in the dissemination of the disease.

7. *Ictonyx orangiae*. (Illustration 5.)

Owing to its nocturnal habits, this animal is seldom encountered, but several members of this species have been trapped at the warrens of *Cynictis*. On the farm Riverside in Edenburg district, where the only case of rabies in a polecat has thus far been discovered, meercats are scarce. It is not suspected that the polecat will play a big rôle in the dissemination of the disease.

8. *Cynalopeex chama*.

Jackals have long been suspected carriers of rabies. In 1934 a European died of hydrophobia contracted from the bite of a dog, which had fought with a jackal three weeks previously at a native kraal. On the 21st September, 1939, the dogs killed a silver jackal on the farm Rooidam, Jacobsdal district. The brain proved positive for rabies. The skin of a similar animal was identified by Dr. Roberts of the Transvaal Museum as that of *Cynalopeex chama*.

In Northern Rhodesia, where the jackal still abounds in great numbers, several cases of rabies have been reported in them; in fact they seem to be the principal vectors there.

In the Union, sheep farmers, in their persistent endeavours to exterminate the destructive Black-backed jackal, have succeeded in reducing the numbers of all three species to a minimum, and over large areas they have been exterminated altogether. In the Karoo, Southern Free State and Griqualand West where the jackal still persists, jackal-proof fencing has been erected at great expense to check raids on small stock.

Although a case of rabies has been discovered in a jackal, it is not suspected that any of the three species play a major rôle in the dissemination of the disease, as not a single case of rabies has been reported in hunting packs, in spite of the large number of jackals hunted by them.

## DESCRIPTIONS OF THE VECTORS OF RABIES.

As the epizootology of rabies in South Africa is very closely associated with the habits, mode of life, migration, food, distribution, burrows and colony-formation of the various wild carnivora, a brief description of each of the species of animals concerned with the dissemination of rabies will be given.

The descriptions which follow are based on those given by Sclater (1900), Fitzsimons (1919), Roberts (1935), Shortridge (1935), Snyman and Thomas (1939), supplemented by the observations of the officers of the Zoological Survey Section and by personal observations.

The sketch map of the Union of South Africa shows, in the different shades, the estimated population density of *Cynictis penicillata* and its distribution.

*The Position of the Viverridae amongst the wild carnivora in South Africa.*

All wild carnivora have always been regarded as inimical to man, consequently the larger and the less elusive species have been exterminated in closely settled areas. They are to-day found only in the sparsely populated or uninhabited parts of the country. The smaller and more elusive species have survived in settled areas, even in the vicinity of towns and villages.

It stands to reason, therefore, that the lion (*Leo leo*), the leopard (*Panthera pardus*), the cheetah (*Acinonyx jubatus*), the hyenas (*Hyaena brunnea* and *Crocuta crocuta*) and the wild dog (*Lycaon pictus*) play no rôle in the rabies problem of this country, but may become of considerable importance, especially the *Lycaon*, which still goes about in large packs and sometimes invades settled areas, should the disease spread to the outlying areas and the game sanctuaries. On the other hand the smaller species composing the *Viverridae* and some of the smaller members of the *Canidae* and *Felidae*, e.g. the jackals and wild cats which have survived in the settled areas and live in close association with man, are greatly concerned with the spread of rabies.

*Cynictis penicillata.*

English: Yellow mongoose, yellow meerkat, red meerkat.

Afrikaans: Rooimeerkat, witkwasmeerkat, witpuntstertmeerkat, geelmeerkat.

Xosa: Igola.

Sotho: Mosa, moswe.

Sechuana: Mushi, musha.

Zulu: N'caciti (*Paracynictis?*).

The genus *Cynictis* belongs to the sub-family *Herpestinae* of the family *Viverridae*, it contains a number of geographical varieties, of which Roberts lists some twelve.

*Distribution.*

The distribution of *Cynictis* extends from the Uitenhage and Alexandria districts in the Cape Province, Northwards through Kafraria where its most Eastern distribution is Kingwilliamstown, thence through the highveld of the Orange Free State and the Transvaal as far as the Drakensberg mountains. From there it extends westward through the Karroo, Namaqualand, Griqualand West, Bechuanaland and Ngamiland into South West Africa, Damaraland (excluding the Namib) up to the Kaokoveld as far as Okovosame, then into western Ovamboland and to the Etosha pan. It does not occur as far North as Grootfontein, S.W.A., and the Caprivi Zipfel. The most thickly populated region is undoubtedly the sandveld of the Western Free State and Transvaal, extending into Vryburg district in Bechuanaland.

Although it has always been regarded as not occurring to the East of the Drakensberg in Natal, I have found a pair in the mist-belt in the Ngutu district about seven miles north of the village. From information obtained from the local natives the *Cynictis*, although very scarce, is known to them and its flesh is relished by piccanins.

In the vast area described above, islands occur in which this species of animal is very scarce or totally absent. One such island appears to be the Eastern slopes of the Gaap mountains up to the Hartz and Vaal rivers, and to some extent on the plateau. I have never seen a yellow mongoose in this area, and this is confirmed by local inhabitants.

*Habitat.*

The areas selected by *Cynictis* are governed by a combination of various factors such as food supply, occurrence of *Geosciurus capensis*, soft or sandy soil, spruities and water courses, open country devoid of dense bush, etc.

(a) *Food supply.*—As *Cynictis* is primarily insectivorous, one usually finds it plentiful in areas where harvesting termites (*Hodotermes*), which forms its principle food, occur in abundance.

The food supply being the limiting factor of all wild life, one often finds the greatest concentration of these animals near farmyards, especially near cattle kraals and the lairs of cattle, where in addition there is an abundance of dung beetles and their larvae. It is not uncommon to find a few colonies near the gates on grazing commonages and outspans where cattle usually congregate. Very frequently on approaching a gate, one sees a creature disappearing into the stone walls protecting the gate-posts, so familiar in some districts of the Free State. The above statement is substantiated by a glance at the map of Trompsburg Commonage.

(b) *Occurrence of Geosciurus capensis*.—Where other warrens are available the yellow mongoose seldom digs its own. It finds it more convenient to take up quarters in the warrens dug by the ground squirrel, and lives side by side with the latter in the same colony. In places where both species abound, the ground squirrel determines where they should live. The squirrel, being dependent on bulbs and grass roots for its food, usually elects to dig its warrens near pans, vleis, and water-courses. The *Cynictis*, although preferring higher ground, takes refuge in such places when suitable. The localities of the colonies marked on the map of the Trompsburg Commonage illustrate this point well. On the farm Philip in the Hoopstad district the majority of colonies inhabited by the yellow mongoose was situated along the shallow pan-like depressions, and many mongooses were also found along the slopes of the big pan.

(c) *Soft or Sandy Soil*.—As has been stated before, the *Cynictis* very seldom digs its own warrens, but it will do so in soft or sandy soil. The actual digging and most of the cleaning up of burrows takes place usually after good rains when the soil is moist and easily worked. Where "trassie-bos" mounds, i.e. mounds resulting from wind-blown sand accumulating around *Acacia stolonifera* bushes, occur, nearly every mound is excavated to form a place of refuge. In these mounds the warrens never penetrate below the ground level. On the farm Sunnyside near Bloemfontein, over which the pipe-line for the town water supply passes, the loose soil over the whole length of the pipe-line is riddled with holes, occupied mostly by *Cynictis*. Whether the pioneer was the squirrel, or not, is difficult to say, but there is no reason to doubt that yellow mongooses were responsible for some of them. On the Trompsburg commonage in the "refuse camp", the refuse heaps are honey-combed with warrens.

Sometimes colonies belonging to *Cynictis* are found on the slopes of very stony hills. At first sight one is inclined to think that they have been burrowed in very hard soil, but on excavation it is found that they have been burrowed among and underneath the large rocks, where the soil consists of soft mould. The warrens are usually not very deep, so that reliance for shelter is placed on the overlying heavy rocks.

(d) *Open Country Devoid of Dense Bush*.—Fitzsimons states that, contrary to the statement that these animals are never found in the bush veld, he has frequently observed them in the bush-veld provided that it is not too dense.

In Vryburg district I have met them in the bush, but invariably found their burrows in the more open spaces, yet amongst taller trees like *Acacia giraffae* devoid of dense shrub. In the Hoopstad district they occur on the sand-bults covered with *Acacia giraffae* and other trees.

Except for very dry seasons *Cynictis* avoids flat low-lying plains, and prefers to inhabit colonies on higher ground or ridges. This presumably is done to avoid the water-logging, that is likely to occur in vleis and other low-lying territory.

The *Cynictis*, although primarily an insectivorous animal, has retained its carnivorous habits. Where the harvester termite (*Hodotermes*) is plentiful, it forms an easily accessible and inexhaustible food supply during the greater part of the year. During the autumn days when these termites are particularly active, the yellow mongoose consumes tremendous quantities of them. In several individuals that have been shot on such days, the stomach was found loaded with *Hodotermes* to almost brusting capacity. At other times, or when termites do not occur, every other type of insect, e.g. grasshoppers, spiders, caterpillar and grubs are preyed upon.

## STUDY AND CONTROL OF THE VECTORS OF RABIES.

The eggs and the young of ground birds are devoured when found. *Cynictis* is often very troublesome near farmyards where fowls are kept, in that it takes a liking to eggs and chickens, and will show great cunning in regularly plundering the fowls' nests. It is also interesting to see how this animal solves the problem of crushing the egg-shell by repeatedly rolling the egg against a stone until it is broken.

Lizards, toads and frogs are also eaten. The *Cynictis* to a certain extent is also a scavenger. A bird, which had been shot and thrown near a colony was first regarded with suspicion, but was eventually eaten. On one occasion a *Cynictis* was seen eating a springhare carcass, killed by a motorist during the previous night. On another occasion a *Cynictis* was disturbed gnawing at the lips and muzzle of a dead ox.

Food is carried to the young in the mouth. Occasionally fur of rodents (rats and mice) is seen in the dung but contrary to popular belief they rarely form its prey, except when found dead or sick and are thus easily caught.

Fourie (1936) has definitely established that its dung is composed entirely of fur during the height of an epizootic among gerbilles, and that it becomes normal again after the subsidence of mortality. The public Health authorities now recognise that, when rodent fur is found in the excreta of the yellow mongoose, it is an indication of plague or some other epizootic effecting small rodents.

Fitzsimons states, that it at times attacks and devours larger prey, and does not hesitate to follow ground squirrels down their burrows to attack and kill them. This is probably not quite correct. I have seen a squirrel attacking and driving a yellow mongoose away from her warren, into which the mongoose endeavoured to escape when it was fired upon. He further states, that it is not uncommon to find a pair of these meercats in possession of a warren of a "jumping hare" or a ground squirrel, the rightful occupants having been either devoured or driven out. From careful observations it has been found that the yellow mongoose will occupy warrens side by side with these animals without disturbing them.

It has been reported on several occasions, that it attacks newly born and weak lambs, and does not hesitate to devour after-births. As a result of the loss sustained by sheep farmers it has been declared vermin, and three-pence is paid by the Free State Provincial Administration for each *Cynictis* tail presented.

The *Cynictis* is mainly diurnal in habit, but has frequently been observed at night. It hunts either singly or in pairs but not in groups, and it may wander as far as two miles from its abode in search of food.

It usually lives in colonies of two to ten or more animals, but a family usually consists of two to five. The females usually give birth to two young at a time, and probably more than once during the same breeding season, as females in full lactation have been found to be pregnant as well. A pair of well fed young mongooses do not look unlike two well fed puppies.

### *Suricata suricatta.*

English: Cape suricate; common meercat; slender-tailed meercat.

Afrikaans: Stokstertmeerkat; gewone meerkat; graaitjie.

Sesuto: Letoli.

Sechuana: Kotoko.

Five geographical varieties are listed by Roberts. The genus *Suricata*, as in the case of *Cynictis*, belongs to the sub-family *Herpestinae* of the family *Viverridae*.

### *Distribution.*

The suricate has more or less the same distribution as the *Cynictis*. Its distribution in the Cape Province is, however, more restricted.

Being essentially a Karoo animal it does not approach the east coast as close as the *Cynictis*, and does not therefore occur in Kaffraria. Its distribution extends more south and north than that of the *Cynictis*, and as far south as Ceres. It is found on the central high veld of the Transvaal, Orange Free State, Griqualand West, and Bechuanaland. Several large colonies have been seen in the Kalahari region of Kuruman district. In South West Africa its distribution is very limited and occurs only in South Damaraland and Gobabis district. Unlike *Cynictis* the distribution of *Suricata* is very even throughout the area where it occurs.

#### *Habitat.*

The suricate, having strong curved front claws, is not like the *Cynictis* dependent on the *Geosciurus* for its warrens. It digs out its burrows in exposed places, preferably on slight elevations to prevent storm water from entering its warrens.

It is, however, unusual to find the suricate occupying the same warrens as the *Cynictis* and the *Geosciurus*. If so, the warrens were probably dug by the latter species.

The suricate is much more migratory in a given locality than either of the other two species of animals, i.e. it wanders within a localized area from colony to colony at short intervals. A large colony was observed near Oliphantshoek, close to a big Camel-thorn tree, along the main road to Kuruman. At times there would be no signs of habitation, and at other times the suricates would be found there again.

The suricate is the most gregarious of the viverrids, and families consisting of ten to thirty or more members are quite common. In one case, on Trompsburg Commonage, a pack of some forty were counted living in one colony.

The migratory habit is probably a necessity to a family of suricates, as they do not wander very far from their warrens in search of food. It stands to reason, therefore, that with a large family traversing only a limited area in close proximity to its warrens, the food supply soon becomes exhausted, whereupon the family has to find a new hunting ground and consequently also a new colony.

Two instances have been described where a migratory pack troop of suricates was followed for some distance. In one a member of the South African Police, on patrol duty on horseback in the Bethulie district, followed a pack of some thirty strong for about two miles along the road. At a turn of the road the suricates carried on, while the police constable turned off. On the farm Elladale in the Umvoti district, Natal, a pair of suricates brought from the Free State as pets, escaped into the veld where they soon multiplied into quite a large family. The farm is situated in the mist-belt, where suricates do not occur. At least two places were known about a mile apart where this family had burrows, which were occupied at different intervals. When one colony was inhabited the other seemed to fall into disuse, but when its turn of occupation arrived fresh excavations were to be found into which the pack would escape on being disturbed. There may have been more such colonies, but only two were located.

#### *Food*

The diet of the Suricate is varied. It consumes both vegetable matter such as corms and rhizomes as well as insects. With its strong claws it can dig out the bulbs it requires, and any insects found are devoured at the same time. On many occasions locusts, grass-hoppers, termites, spiders, tarantulas and centipedes have been found amongst the stomach contents of suricates that have been shot.

The breeding period is probably throughout the year and litters of as many as five young have been found in one nest.



## STUDY AND CONTROL OF THE VECTORS OF RABIES.

### *Myonax pulverulentus.*

English: Small grey mongoose; Pepper and Salt cat.

Afrikaans: Klein-grys-kommetjiegat; Neuthaar, Garkie.

Xosa: Iitse.

Sesuto: Mayewane.

The genus *Myonax* belongs to the sub-family *Herpestinae* of the family *Viverridae*.

As a result of its comparative local distribution two varieties only of *Myonax pulverulentus* are described, one of the North West Cape and one of Little Namaqualand.

#### *Distribution.*

The *Myonax pulverulentus* is practically restricted to south of the Orange River, where it is widely distributed. Fitzsimmons gives it as common throughout the Cape Province and Natal.

#### *Habitat.*

Its favourite haunts are the bush-veld and rocky vegetation hillsides. Nests are found in the crevices of rocks and hollow tree stumps, where the animals live in pairs.

#### *Food.*

Its diet consists of rats, mice and insects. It will approach fowl-runs and catch young fowls. It is a pastmaster at killing snakes. Fitzsimmons on one occasion introduced a puff-adder into the cage of a *Myonax*; a battle ensued with the result that the snake was killed, and starting from the head the *Myonax* devoured its victim. It is further described as having a most important mission in the economy of nature, for of all creatures it is the most persistent in its pursuit of rats, mice, and noxious insects and should for this reason not be molested.

### *Genetta felina.*

English: Cape spotted genet; Genet cat (Vryburg).

Afrikaans: Muskejaatkat; Misselkat; Muskkat; Mosaliatkat.

Zulu: Insimba.

Swazi: Insimba.

Xosa: Inyawagi.

Sesuto: Thsipa.

Sechuana: Tsipa.

The genus *Genetta* belongs to the sub-family *Viverrinae* of the family *Viverridae*.

Roberts lists two varieties of *Genetta felina* in South and Tropical Africa.

#### *Distribution.*

The *Genetta felina* is the most widely distributed of South African genets, being found from the Cape to the Zambesi and beyond.

#### *Habitat.*

Being nocturnal in habits and very secretive, the spotted genet is very rarely seen and encountered. Its habitat is therefore not fully determined. It seems from the number of rabid cases reported from Vryburg, that it is very plentiful in Bechuanaland. It seems to favour well sheltered bushy parts with thick undergrowth. Near Bloemfontein, on the farm Hill-and-Dale it is plentiful. In one year dogs killed no less than five. The farm consists mostly of dolorite koppies overgrown with cactus.

Unless it wanders a great deal it prefers to be near farm-yards to obtain easy prey in the form of chickens.

*Food.*

The food of the genet consists of any creature it can overpower, hares, rats, mice, birds with their nestlings and eggs, fowls from farm-yards, etc.

*Felis spp.*

English: Wild cat; Black-footed cat.

Afrikaans: Wildekat; Groukat; Vaalboskat. Swartpootkat.

Zulu: Impaka, Isobila.

Xosa: Ingada, Inxataza.

Sotho: Paka; Mokube.

In the *Felis spp.* are included the two species *Felis ocreata caffra* and *Microfelis negripes negripes*, of the family *Felidae*. Of the first named species Roberts lists four and of the latter two geographical varieties.

*Distribution and Habitat.*

The distribution of both species of *Felis* is very wide. The *Felis spp.* are found from the Cape to beyond the Zambesi, and frequents hilly country and thick undergrowth where abundant shelter is found during the day.

*Food.*

Both the species are essentially carnivorous and prey on any animal or bird they can catch. Mice and rats and small birds are very easily caught by these cats. Fowl-houses are frequently visited, from where they will take a fowl and devour it nearby.

*Geosciurus capensis.*

English: Ground squirrel; Bush-tailed or Fan-tail meercat.

Afrikaans: Waaierstert meerkat.

Sechuana: Samane.

The ground squirrel (*geosciurus*) a rodent, belongs to the family *Sciuridae*. Three varieties have been listed by Roberts.

*Distribution.*

The distribution of *Geosciurus capensis* is fairly general. It occurs over the whole of the Karoo, Namaqualand up to Ngamiland, including the Kalahari. It is very widely distributed over the high-veld of the Transvaal and Orange Free State, especially in the western parts of these provinces.

*Habitat.*

The ground squirrel prefers the plains and is very seldom found in hilly country, but may burrow at the foot of isolated hills. Being dependent on bulbs and tubers it congregates near pans and water courses, digging its warrens on the slopes.

Its strong and well-developed front claws are well adapted to dig extensive warrens in fairly hard soil and shale. In the Kalahari it prefers to burrow in lime-outcrops between the sand dunes, as it is probably difficult to keep the burrows open in the loose sand. Where mealie fields exist colonies of the ground squirrel are usually found nearby and even in these fields.

It is generally accepted that this animal does not go far afield for its food but grazes in the vicinity of its burrows. On several occasions squirrels have been caught at their burrows situated more than 800 yards from mealie-fields, with the stomach contents showing that they had fed on mealies.



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The ground squirrel is a sociable animal, living in groups up to eight or more in the same colony. Where unsuitable ground exists for digging warrens as in the isolated lime-outcrops in the Kalahari the offspring remain with their parents, so that the groups increase to twenty or more animals occupying the same colony. The breeding season continues probably right through the summer. The squirrel is very careful about its nests, which consist of chambers dug out of the tunnels and filled with soft grass and other fluffy material which it can obtain.

### Food.

The diet of the ground squirrel which is entirely vegetable, consists mainly of "uintjies" and other rhizomes, corms, tubers, gourds, cactus-leaves, grain and grass seeds, etc. Great damage can be done in mealie-fields when these are near the colonies; especially is this the case in newly planted fields where row upon row of the seed is dug up as soon as it has germinated and the green shoots appear above the ground.

### *Ictonyx orangiae.*

The genus *Ictonyx* of the family *Mustelidae* is represented in South Africa by three species, viz., *Ictonyx striatus*, *I. kalaharicus*, and *I. orangiae* with several varieties. Roberts lists five of the first species, three of the second and four of the last named.

The three species are commonly not differentiated and are referred to collectively as "Polecats", or "Skunks".

English: Polecat; Skunk.

Afrikaans: Stinkmuishond.

Sechuana: Nakedi.

Sesutu: Thikgoe.

Zulu: Igaga.

Xosa: Igaga.

### Distribution.

The striped polecat is found over the whole of Africa, and is the most ubiquitous of all animals, being equally at home in mountains, waterless sand planes, the Karoo, the bushveld, and swamps. The other two species of polecats have a comparatively limited distribution. *Ictonyx kalaharicus* occurs in the Kalahari region of Bechuanaland and South West Africa. *Ictonyx orangiae* extends over the O.F.S., Namaqualand, Transvaal, Zululand, and Ghansi to Damaraland.

### Habits.

The polecats are of solitary and nocturnal habits, occasionally hunting in pairs. A family of these was encountered at night in the midlands of Natal. During the day they hide in crevices and burrows, and although terrestrial, can scramble into trees. The characteristic nauseating odour given off when they are frightened or attacked originates from a fluid secreted in the anal glands. The stink adheres to dogs for days after they have killed a polecat.

### Food.

Polecats are more essentially carnivorous than mongooses, they prey very largely on rodents which they often dig out of their warrens. They kill and devour snakes, lizards, the nestlings of terrestrial birds, and are at the same time fearless poultry raiders.

Owing to their persistent destruction of small rodents, they should be protected, as they render valuable service in keeping down the numbers of the gerbilles which are largely concerned with the dissemination of Bubonic plague.

*The Jackal.*

Although there is a big difference between the three species of jackals found in South Africa, they are very often confused. The three species are *Otocyon megalotus*, *Cynalopex chama* and *Thos mesomelas*. *Chaeffia adusta*, which is unknown in the rabies areas, occurs in the tropical parts of Zululand, Rhodesia, and further north.

*Otocyon megalotus.*

English: Desert fox; Cape Fennec.

Afrikaans: Draaijakkals; Bakoorjakkals.

Sechuana: Mathlose; Maclusi.

*Distribution.*

Two geographical varieties are listed by Roberts. The *Otocyon* occurs in dry western parts of South Africa, viz.: on the Karoo plains, Bechuanaland, North-western Transvaal, and South West Africa. In the Kalahari region, where it occurs in great numbers, the natives hunt them for their pelts, for which they obtain two shillings a piece.

*Habits.*

It is nocturnal in habit, but ventures in daylight into the more secluded parts of the country.

*Food.*

The animal, although listed as vermin and for whose destruction a reward is paid, is really a harmless animal. Its diet consists mostly of termites, beetles, locusts, small rodents, lizards, and the eggs and nestlings of terrestrial birds. Farmers in the Karoo maintain that it catches new born lambs. Owing to its destruction of Gerbilles, which play such an important rôle in the dissemination of bubonic plague, it should really receive protection.

The sheep farmers unfortunately, in their endeavours to exterminate the destructive Red or Black-backed jackal, have almost completely exterminated this animal, as it is less elusive than the former.

*Cynalopex chama.*

English: Silver jackal.

Afrikaans: Silwer, Vaal or Draai-jakkals.

Sechuana: Losi.

Sesutu: Mopheme.

*Distribution.*

The distribution is more or less the same as that of the Cape Fennec, but it is nowhere common. Its range is restricted to South Africa south of the Zambesi, it occurs on the Cape Flats, the Karoo, Orange Free State, Western parts of Transvaal, Bechuanaland, South-West Africa, but not beyond north of Grootfontein, and does not occur in the Caprivi Zipfel. It is also absent east of the Drakensberg.

*Habits.*

Being of a secretive disposition and nocturnal in habit, it is very seldom seen. During day-time it lies hidden in the thick undergrowth, preferably in thick matted thorny bushes and concentrates round the base of hills and kopjes for shelter. It is less easily caught by dogs than the "bakoor".

*Food.*

The diet is the same as that of *Otocyon*, but it is claimed by farmers that *Cynalopex* is more destructive to lambs, catching fairly strong ones.

## STUDY AND CONTROL OF THE VECTORS OF RABIES.

### *Thos mesomelas.*

English: Common jackal, Black-back, Silver-back or Saddle-back; Red or Cape jackal.

Afrikaans: Rooi- of Swartrugjakkals; Saalrugjakkals.

Sechuana-Sesutu: Phokojoe.

Xosa: Impungutshe.

Zulu: Nkanka.

### *Distribution.*

This is the commonest jackal, and occurs everywhere from the Cape to the Zambesi.

### *Habits.*

This animal, although nocturnal in habit will venture out in day-time as well. It hides in dense scrub and in hilly country, where it can find suitable shelter.

### *Food.*

It is more carnivorous than either of the other two species of jackal. It subsists mainly on rodents and wild birds, besides being a scavenger. In spite of its being a scavenger it is very seldom caught in traps or killed with poisonous bait, as it is exceedingly cunning and has a very fine scent. It is most destructive to the sheep farmer, catching and killing young sheep. On account of this destructive habit it has cost sheep farmers thousands of pounds through loss of sheep and the protective erection of jackal-proof fencing.

## PART II.

### PREVIOUS ATTEMPTS AT DESTRUCTION OF THE VECTORS OF RABIES.

As early as 1930 (Neitz and Marais, 1932) it was realised that rabies was firmly established in some of our wild animals, and especially in the *Viverridae*. In order, therefore, to reduce the incidence of rabies an extermination campaign of meercats on infected and adjoining farms by gassing with cyanide was undertaken by the Department. From February, 1930, to June, 1931, forty-three farms in the Transvaal, Orange Free State, and the Cape Province were treated.

White (1932) in his report on the above campaign made two statements which dispelled all hopes of success, and as a result of which the campaign was abandoned. In the first place he mentioned that reinfestation by meercats of a treated farm, took place even before the gassing operations on that farm were completed. In the second place failure was ascribed to the fact that the gas, especially after abundant rains, was not always effective.

It is also noted that outbreaks of rabies reoccurred on some of the infected farms on which the extermination of meercats had been undertaken, e.g., Cyfergat, in the Wolmaransstad District on 20.8.36; in the Orange Free State at Dealesville on 16.6.32, and subsequently at Kromsprit on the 4.11.35, and at Brandfort on 18.9.35.

Thornton (1935) described the want of success in destroying veld rodents in connection with plague control, as due to (1) the use of spent dust or defective equipment; (2) the preliminary closing up of the entrances, thus preventing effective penetration of all the underground passages by the dust; (3) the treatment of apparently occupied warrens only, and the neglect of deserted or spare warrens, and (4) the gassing of burrows while the ground is saturated with moisture, or while the animals are out feeding.

### STUDY OF THE STRUCTURE OF MEERCAT BURROWS.

In 1936, when it seemed that the incidence of rabies was increasing, and it was realised that all measures of control would fail unless the disease was checked in the wild carriers, experimental work was planned and carried out with a view to discovering the best means of achieving this.

It was obvious, that an accurate knowledge of the internal structure of the colonies and burrows was required, in order to devise the best methods for fumigation, and to determine the causes of failure to kill these animals in the warrens.

A preliminary investigation was started near Wesselsbron, where an outbreak of rabies had occurred. These preliminary investigations, conducted under the direction of Dr. Thomas, consisted chiefly of studying the formation of the colonies and the structure of the burrows of the *Cynictis*, *Geosciurus*, and *Suricata*.

A considerable number of colonies, both small and large were dug up, during the course of these and subsequent experiments, and they were described and sketched to scale.

#### PROCEDURE FOLLOWED IN THE STUDY OF BURROWS.

The procedure adopted was shortly as follows: Two wires were stretched at right-angles across the colony, and staked. These wires then represented the co-ordinates. Corresponding co-ordinates were drawn on graph paper. The most convenient scale was found to be five feet to the inch.

The positions of the openings of the warrens were measured from the co-ordinates with a tape-measure and were marked as small circles on the sketch. Digging operations were then started at one or more openings, and the warrens were carefully followed. As the digging progressed, the depth and directions of the warrens were measured in the same way from the co-ordinates, and traced on the graph paper as accurately as possible.

#### DESCRIPTION OF THE BURROWS.

The three above-mentioned species of burrowing animals dig their burrows very much on the same intricate pattern, which is more easily illustrated than described.

STUDY AND CONTROL OF THE VECTORS OF RABIES.

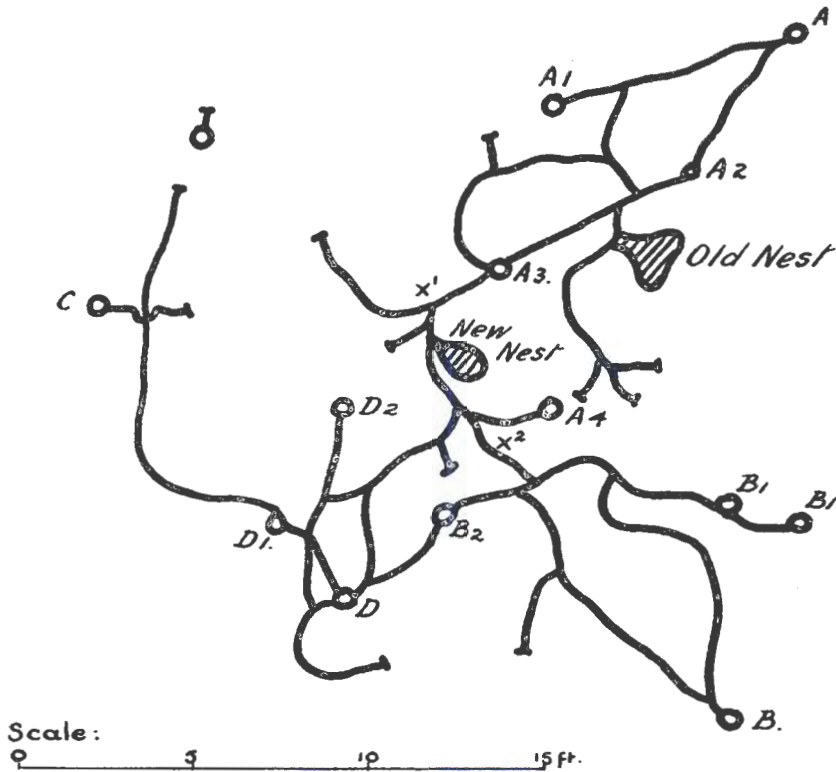
Sketches 1, 2 and 3 represent very simple colonies. The first dug and inhabited by *Geosciurus*, the second by *Suricata*, while the third was inhabited by *Cynictis*. Sketch 4 is typical of colonies of the more complicated nature.

The colony usually consists of a number of holes dug at an angle of about 30 to 40 degrees to the surface for a depth of two to three feet, according to the nature of the soil.

In cross-section the hole is roughly half-moon shaped approximately 3 inches high and 4 inches wide.

SKETCH 1.

*Sketch-plan of a Simple Colony Inhabited by Geosciurus.*



The colony, which was located on Trompsburg Commonage, was gassed with Cyanogas and dug up 4½ hours later.

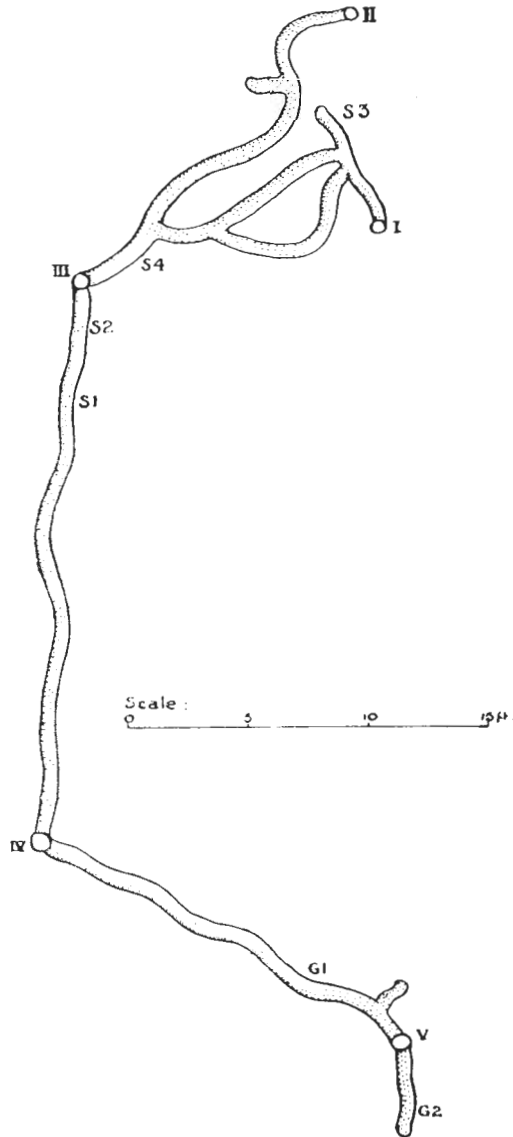
*Reference:—*

A dead *Geosciurus* was located at X<sup>1</sup>, and a live one in a dazed condition at X<sup>2</sup>.

A and B indicate the holes into which the gas was blown with a single action hand-pump.

SKETCH 2.

*Sketch-plan to Scale of a Meercat Warren on Vryburg Commonage. Gassed with Cartridge Fumigators and dug up on 15.11.38.*



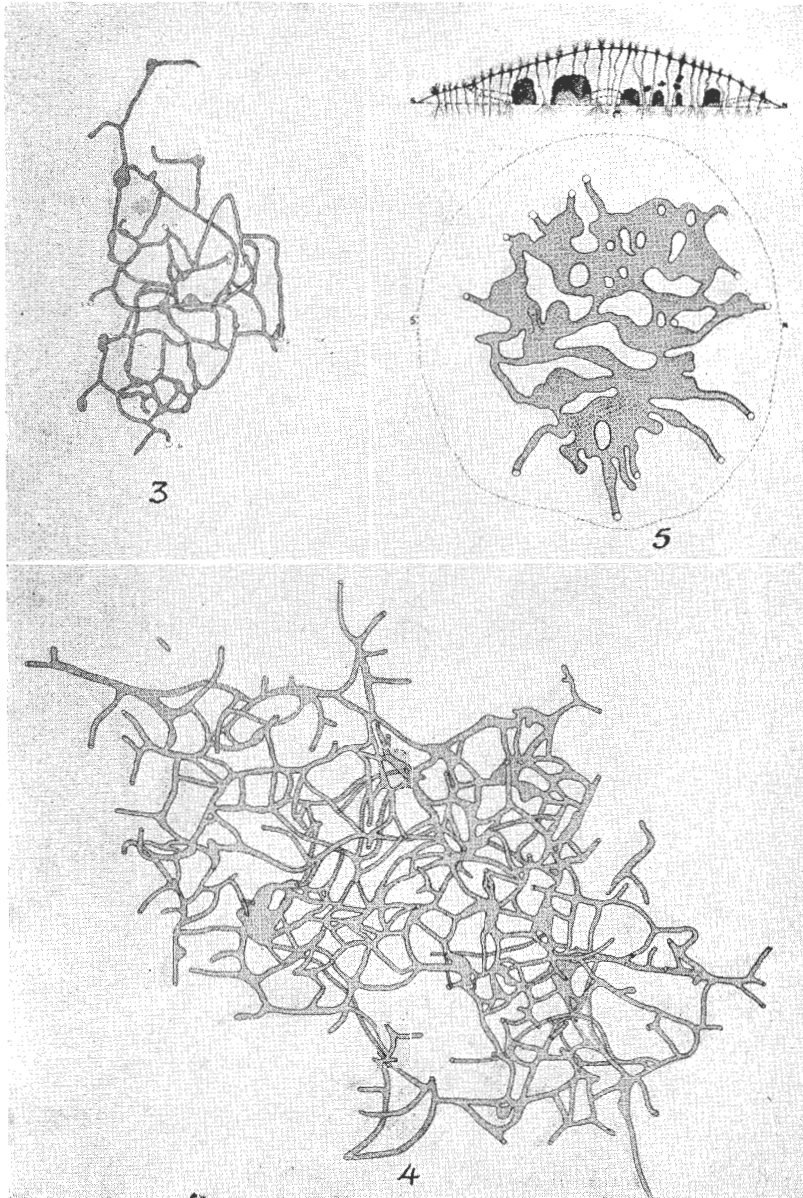
*Reference:—*

S1. indicates point where Suricates escaped.

S2 and S3, etc. indicate points where live Suricates were located.

G1 and G2 indicate where dead Geosciurus were located.





Sketch 3.—(Top Left.) Sketch-plan of a simple colony inhabited by *Cynictis*. The colony was dug up immediately after gassing, and a *Cynictis*, still alive, was located in the cul-de-sac at the top of the illustration.

Sketch 4.—(Bottom.) Sketch-plan of a typical meercat colony of a more complicated nature. The colony was gassed after three *Cynictis* were seen to enter it, and then dug up. Six *Cynictis* and two *Geosciurus* were found dead in the burrows.

Sketch 5.—(Top right.) Sketch-plan and section of meercat warrens in a "Trassiebos" mound. The large confluent chambers are due to constant caving in and removal of soft earth.

At more or less the same level underground, the tunnels are interconnected to form a maze or network. At intervals chambers are formed, lined with soft grass, forming the breeding and sleeping places. It has been found very frequently, when colonies were dug up, inhabited both by the squirrel and the yellow mongoose, that in the part inhabited by the former the bedding in the chambers consisted of fresh straw, while in the chambers occupied by the latter the bedding was old and in a decayed state or no bedding at all was present. It is evident, therefore, that the squirrel carefully prepares its breeding-chamber, while the yellow mongoose is satisfied with what it can obtain in sections vacated by the squirrel.

A very remarkable feature is that the tunnels are more or less on the same underground level, only occasionally does one find a tunnel passing under another, and thus failing to connect up or only connecting up when it has been down for a considerable distance, when it passes upwards again. The tunnels which do not connect usually end in a chamber. A feature, which was found to have an important bearing on the gassing (to be described later) of the colonies, was the presence of unconnected tunnels ending in cul-de-sacs, usually situated at the periphery of the colony and in an extension 30 feet or more long. Such a tunnel is well illustrated in sketch 3 extending towards the top. In a colony that has been exploded by dynamite and afterwards dug up, a tunnel thirty feet long was revealed, at the end of which a female suricate with a litter of five was detected.

There seems to be no limit to the size of the colonies. New holes and tunnels are added from time to time as the older portions are abandoned, or as the squirrel has to make room in its quarters for the yellow mongoose. Colonies, containing as many as a hundred or more openings, measuring fifty yards in diameter are frequently found. In such cases only a few of the openings on the periphery show signs of being in use.

Fresh excavations on new colonies or extensions to existent ones are only seen after rains, when the soil is soft and easily worked. Cleaning up the holes, which have partly caved in, also takes place at such times.

It can, therefore, easily be realised to what extent a colony situated in a favourable site and position, may increase by extension year after year. On the farm Beestekraal a colony has been dug up whose existence was known to the owner of the farm for at least fifteen years. The colony roughly measured 80'  $\times$  105' and had about 90 openings.

As has been pointed out before, the *Geosciurus* prefers to dig its own colony, and will not, like the *Cynictis* take refuge in any kind of hole. The latter will only dig its own warren when it cannot find anything else to take refuge in. A pair of *Cynictis* was once found to have taken up their abode in an old caved-in antbear hole, to which they had made a side entrance. They also make



use of refuse heaps, boulder heaps like those found as support for gate posts. Graves in neglected farm cemeteries are favoured by the *Cynictis* as the stones covering the loose soil in which they dig, afford a very good protection. Springhare warrens, both abandoned and inhabited, often harbour meercats too.

A very favoured abode is in the wind-blown sand mounds called "Trassie-bos" in Afrikaans. These mounds are formed by sand blown into and held by a thorny shrub *Acacia stolonifera*. As the sand-mound increases, the shrubs grow out and so catch more sand. Such mounds may reach a height of three to five feet and obtain a diameter of ten to twenty yards. The holes dug into the soft moist sand eventually collapse in dry weather, but the burrowing animal, being enticed by the soft soil and good drainage, persists in cleaning up and excavates large confluent chambers in the mound, the soil or sand roof being supported to some extent by the roots of the shrub, forming pillars or columns with sand packed around it. The burrows are therefore above the level of the ground. (Sketch 5.)

On the Trompsburg Commonage the town refuse-heaps deposited there were found to harbour *Cynictis*. One of the mounds selected for excavations was about 50 yards long and about 20 yards wide, and consisted mainly of coal-ash and refuse from dust bins. The average height of the ash above the ground level, where the openings and tunnels were made, was about 20 ins.

Slightly more than one inch of rain had fallen four days before the excavations were made. Three openings were freshly cleaned out, the ash being still moist. Two *Cynictis* were seen to enter into one of these on our arrival.

As the whole of the refuse mound could not be dug up, the warrens over an area of about 20 yards on either side of the freshly cleaned out warrens were gassed and the openings closed, and digging operations were started from the freshly cleaned-out warrens.

About half an hour after the time when the digging operations had been commenced, a *Cynictis* escaped from an opening which was 22 yards away from the starting point.

The ash was damp right through. The warrens extended obliquely down to the ground-level, but nowhere did they go beyond the ground-surface. The tunnels were very easy to follow in some places where the ash was comparatively solid. In others again the tunnels had partly caved in and were difficult to follow.

The network resembles an ordinary colony, but with the difference that the tunnels have less interconnections and are therefore longer. Several breeding chambers were uncovered, but in none of them was fresh straw or bedding found. This indicates that ground squirrels had dug or occupied these warrens.