

PLAGUE IN SOUTH AFRICA: PERPETUATION AND SPREAD OF INFECTION BY WILD RODENTS.

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THE infection of plague was originally introduced into South Africa during the Anglo-Boer War, 1900–1902, by rats from vessels with cargoes of forage from infected South American ports. During this period serious outbreaks occurred in Cape Town, Port Elizabeth, East London and other centres in the Cape Province, and also at Durban and Maritzburg. Further outbreaks—at Kingwilliamstown, Queenstown and elsewhere—occurred in 1903, and in 1904 a considerable outbreak occurred in Johannesburg and neighbourhood. The infection persisted at Port Elizabeth, East London and Johannesburg up to 1905.

In all these outbreaks the epidemic in man was associated with, and for the most part caused by, a plague epizootic amongst the local rodents. This was mainly confined to rats, both black and brown, and to ordinary domestic mice, but during the outbreaks at Knysna, Mossel Bay and Graaff Reinet, specimens of wild “striped mice” (*Arvicanthus pumilio*) were found dead of plague on the outskirts or in the vicinity of the infected towns. The mortality among these animals was most marked at Knysna. The forest and bush in the neighbourhood of the town teemed with these animals and an extensive plague epizootic occurred amongst them, infected specimens being found as far as 18 miles from the town.

During the period 1906–1911 no plague in man or animals was discovered in the Union, but in 1912 an outbreak occurred at Durban, comprising 32 cases with 26 deaths, concurrently with a plague epizootic amongst rodents in the dock area and in three or four localities in the town. The precise source of infection was not traced, but there is no reason to doubt that it was introduced by infected rats from vessels from eastern ports.

In 1914 a very virulent outbreak, mainly of pneumonic type, occurred amongst persons living on a remote farm in the Tarka district of the Cape Province. None of the persons first attacked had recently been away from the farm and no clue to the source of infection could be discovered. Considerable spread took place—the neighbouring districts of Queenstown, Middelburg and Glen Grey being affected, and later, the Uitenhage district. In these districts in 1914 there were 35 cases with 31 deaths; in 1915, 45 cases with 26 deaths; in 1916, 24 cases with 13 deaths; and in 1917, 2 cases—both fatal. All the

foregoing cases occurred on farms and in native locations in the rural parts of the districts where ordinary domestic rodents were very few or entirely absent; no trace of infection of wild rodents or other animals could be discovered. No case of plague is known to have occurred in the Cape Province since 1917.

In 1916 cases of plague began to occur on scattered farms in the Hoopstad, Winburg and Senekal districts of the Free State, totalling during the year 37 cases with 23 deaths. This prevalence continued during 1917, when 29 cases with 21 deaths occurred in the same districts, with an extension to the neighbouring Transvaal district of Potchefstroom, where 15 cases—14 of which were fatal—occurred. During 1918, 2 cases, both fatal, occurred in the Hoopstad district. In none of these outbreaks could the original source of infection be traced. The late Dr D. C. Rees who was for a time, jointly with Dr Targett Adams, in charge of plague work in the Free State emphasised the danger of mild ambulatory cases, and in a report dated 25th April, 1916, cited instances where the *bacillus pestis* in virulent form was present in the sputum of pure "bubonic" cases for as long as two months after recovery. But in many of these outbreaks no evidence of human conveyance could be traced, and in some the circumstances were such as to render this mode of conveyance highly improbable; also, it would be difficult to account for the persistence of infection in these districts over several years if the disease affected the human population only.

After the two cases in the Hoopstad district in September, 1918, there was a period of 18 months during which nothing suspicious occurred, and it was hoped that the infection had disappeared. But in March, 1920, an outbreak occurred amongst natives on the farm "Angra Pequina" in the Bothaville area of the Kroonstad district, 25–30 miles distant from farms in the Hoopstad district where cases occurred 18 months to two years previously. Despite careful investigation, the source of infection remained a complete mystery. During the last two months of 1920 several cases occurred on two farms in the Hoopstad district—near farms which had been infected two or three years before. Since the beginning of the present year, seven further small outbreaks have occurred in the Bothaville area of the Kroonstad district and the northern part of the Hoopstad district adjoining.

Careful inspections and investigations last year failed to disclose any evidence of plague amongst rodents. The ordinary species of domestic rodent are practically non-existent in the rural areas of these districts. It was felt, however, that there was strong presumptive evidence of some undiscovered agency in the persistence and spread of the infection. The Departmental records and reports of the outbreaks in the Free State from 1916 onwards were carefully scrutinised and reviewed by Dr Haydon and myself, and the seats of the outbreaks plotted on a large scale map. Subsequently, a general inspection of the area was made by Dr Haydon. Arrangements were made with the authorities of the Pretoria Museum for a rodent survey of the area

to be carried out by Mr Austin Roberts, Naturalist to the Museum, with the assistance of Mr Powell, an expert tracker and trapper. A valuable report on the rodent and small carnivora populations of the area was furnished by Mr Roberts. During the course of his investigations several decomposed or dried-up carcasses of wild rodents were found, and the fresher of them submitted to the South African Institute for Medical Research, Johannesburg, for examination, but with negative results. It was found that the gerbille or "nacht-muis" (*Gerbillus taterona*) was very numerous in many parts of the area, also the multimammate mouse (*Rattus coucha*), the large-eared mouse (*Malacothrix typicus*), and the striped mouse (*Arvicanthus pumilio*), together with the yellow mungoose (*Cynictus penicillata*), the ground squirrel (*Geosciurus capensis*), and the suricat or true meercat.

On going further into the matter we found that the distribution of outbreaks corresponded roughly with the areas or sandy stretches in which gerbilles were especially prevalent, and other circumstances came to light concentrating special suspicion on these animals. Evidences of recent migration of gerbilles and desertion of burrows were also found, and in a few instances dried-up or mummified carcasses or skeletons of dead gerbilles. Owing to the activities of the small carnivora, birds and ants, the carcasses of animals dying in the open generally disappear very quickly.

Search parties under the direction of Mr Powell, the expert tracker and trapper, with Dr Sheldon and, later, Dr Leviseur, as Plague Medical Officers in local charge, were organised by the Department. A large number of burrows in likely places were dug out and arrangements made for using healthy wild rodents as bait, by placing them in cages near suspected burrows in the hope that they would exchange fleas with the inmates of the latter, but for long the results were negative.

The habits of the gerbille are purely nocturnal, so that they are rarely seen by man; also, they rarely or never enter dwellings. They are gregarious and migratory and often travel long distances at night, either singly or in parties. The almost complete destruction of jackals, lynxes and cats and the great development of mealie-growing have created conditions exceptionally favourable to wild rodents in this part of the Free State. The place of the ordinary domestic mouse is taken by the multimammate mouse, which lives sometimes in gerbille burrows and sometimes in dwellings or outbuildings, or, again, it may alternate between the two. It is a lazy animal, never travels far, and prefers any cover, or the hole or burrow of some other animal, to digging a hole for itself.

It was further found that these and other veld rodents, and the small carnivora living in association with them, were flea-infested, especially during the summer time. A collection of fleas and other ecto-parasites of these animals was made; the species have since been identified and include a number of fleas which bite man (see list annexed, for which I am indebted to Mr G. A. H. Bedford, Entomologist, Veterinary Research Institute, Onderstepoort, Pre-

toria). Healthy specimens of these animals tested at the South African Institute for Medical Research, Johannesburg, were found to be highly susceptible to plague. In the bulletin issued by the Department for the week ended 4 December, 1920, it was stated:

The general circumstances of the recurring small outbreaks of Plague since 1916 in the north-western part of the Orange Free State and neighbouring part of the Transvaal suggest that the infection exists amongst and is being perpetuated and spread by wild rodents; the gerbille or nachtmuis, the large-eared mouse (*Malacothrix*) and the veld muis (*Multimammate Mouse*) are especially suspect. Notwithstanding careful search and investigation, however, no direct evidence of this has so far been found. The investigations and precautions are being continued.

In February last the owner of the farm "Grootdraai," close to Bothaville, and about eight miles from "Angra Pequina," became ill and died of plague. Around his homestead were a number of gerbille burrows, but the inmates of these were healthy. For a week or 10 days before the onset of his illness the farmer had been ploughing on lands some three miles from the dwelling and was wont to have a mid-day siesta under the shade of a clump of bush near by. This locality was searched and several recently dead gerbilles and multimammate mice were found on the ground surface; there was also a large colony of burrows. These were excavated and a total of eight dead gerbilles found—the remainder having evidently migrated. There were also found between 350 and 400 multimammate mice, of which 150 were recently dead and 100 were obviously sick; the remainder were kept in captivity and most of them died during the succeeding week. Specimens of the dead gerbilles and multimammate mice and also of the mice which died in captivity later on were sent to the South African Institute for Medical Research, Johannesburg, and found to be plague-infected. Thus ended successfully a long and tedious investigation.

Since then, plague-infected gerbilles and multimammate mice have been found on another farm, "Dwaalfontein," in the Bothaville district, on which cases of plague had occurred—also on the farm "Cato's Vlei" in the Hoopstad district. Dried-up or decomposed carcasses of gerbilles, multimammate mice and malacothrix have been found on several other farms in the area, but all were useless for bacteriological examination.

So far the only species in which plague infection has been definitely found are gerbilles and multimammate mice. Two dried-up carcasses of ground squirrels have been found on a farm on which plague-infected gerbilles were discovered. As yet no definite evidence incriminating the small carnivora, such as the mongoose and muishond, has been found.

There is little doubt that plague infection has existed amongst the wild rodents in the north-western part of the Free State since 1916, the gerbille being probably the main factor in its persistence and spread, the multimammate mouse being in many cases the connecting link by which infected fleas were conveyed to man.

The area at present involved is, roughly, that bounded on the north by the Valsch River, on the west by the Vaal River, on the east by the main railway line, and on the south by the Vet River with a strip of infected country on its lower side—a total area of about 5000 square miles.

The elucidation of the chief mode of persistence and spread of the infection is an important step in the direction of limitation and eradication, but the problem is still a very difficult one and the risks of spread to the wild rodents in neighbouring districts and to the domestic rodents in the towns and villages, or its conveyance by rail or otherwise to some of the large towns, are very great. Ordinary methods of poisoning and trapping are quite useless for dealing with these animals; gassing with carbon bisulphide is the most effective means we have yet been able to devise.

No plague in man or rodents has been discovered since April last, but with the return of warm weather and the increase of insect life a recrudescence of the disease may be expected.

Plague is known to have occurred and persisted in enzootic form amongst wild rodents in other countries. Some years ago in California the disease was proved to exist amongst ground squirrels (*Citellus Beecheyi*), and the original source of infection of the terrible Manchurian epidemic of pneumonic plague of the winter of 1910–1911—in which some 50,000 cases occurred without a single recovery—is believed to have been the Tarbagan or marmot (*arctomys*). I understand that certain species of gerbille are common in India and it seems possible that our investigations in South Africa may throw light on some of the plague problems of other countries.

The original source of infection of the wild rodents in the north-western Free State must remain a matter of surmise. Natives from Tarka, Queens-town and neighbouring districts of the Cape Province sometimes go to work on the farms in the Free State, and the infection may have been introduced in 1916 in this way and conveyed from man to rodent by fleas. On the other hand, however, it seems well within the bounds of possibility that the infection has existed amongst wild rodents in certain parts of the Union since the outbreaks of 1903, and that the outbreaks in the Tarka and other midland districts of the Cape Province in 1914–1917 were caused in the same way. At first sight one would expect that had the infection so persisted, outbreaks would have been more frequent and continuous, but it must be borne in mind that the complicated chain of infection between rodent, flea and man can, in the nature of things, rarely be completed.

*Plague in South Africa**List of Fleas collected from wild rodents and small carnivora in North-Western Free State.*

ANIMAL HOST	FLEAS
<i>Tatera Lobengulæ</i> (Gerbillæ)	<i>Dinopsyllus lypusus</i> <i>Xenopsylla eridos</i> <i>Listropsylla stygius</i>
<i>Rattus coucha</i> (Multimammate Mouse)	<i>Dinopsyllus lypusus</i> <i>Echidnophaga larina</i>
<i>Rattus rattus</i>	<i>Xenopsylla cheopis</i>
<i>R. rattus fruginis</i>	<i>Xenopsylla brasiliensis</i>
<i>Arvicanthus pumilio</i> (Striped Mouse)	<i>Dinopsyllus lypusus</i> <i>Xenopsylla eridos</i> <i>Chiasropsylla octavii</i> <i>Listropsylla stygius</i>
<i>Laggada</i> sp.	<i>Dinopsyllus lypusus</i>
<i>Malacothrix</i> sp.	<i>Listropsylla stygius</i>
<i>Steatomys</i> sp.	<i>Listropsylla stygius</i>
<i>Xerus</i> (<i>Geoscirus</i>) <i>capensis</i> (Ground Squirrel)	<i>Xenopsylla isidis</i> <i>Echidnophaga bradyta</i> <i>Echidnophaga gallinaceus</i> <i>Ctenocephalus canis</i>
<i>Cynictus penicillata</i> (Yellow Mongoose)	<i>Echidnophaga bradyta</i> <i>Xenopsylla isidis</i> <i>Echidnophaga gallinaceus</i> <i>Ctenocephalus canis</i> <i>Listropsylla stygius</i>
<i>Pedetes caffer</i> (Spring Hare)	<i>Xenopsylla</i> nov. sp.
<i>Suricator suricator</i> (Suricat or True Meercat)	<i>Ctenocephalus canis</i> <i>Echidnophaga gallinaceus</i>