Report of the tenth outbreak of plague at Sydney, New South Wales, 1921-22.

[*EXTRACT from the Report of the Director-General of Public Health, New South Wales, for the Year ended 31st December*, 1922.]

SECTION I—B.

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REPORT ON THE TENTH* OUTBREAK OF PLAGUE AT SYDNEY, NEW SOUTH WALES, 1921–22.

Part I.—Epidemiology and Administration. By W. G. Armstrong, M.B., Ch.M. (Sydney), D.P.H. (Camb.), Director-General of Public Health.

Part II.—Treatment of Cases at the Coast Hospital, with Notes on Use of an Anti-Plague Serum. (Biological Institute of Australia.) By R. J. Millard, M.B., Ch.M. (Sydney), D.P.H. (Camb.), C.M.G., C.B.E., Medical Superintendent, Coast Hospital.

Part III.—Pathological and Bacteriological Investigations. By E. W. Ferguson, M.B., Ch.M. (Sydney), Principal Microbiologist, Department of Public Health.

Part I.—BUBONIC PLAGUE—EPIDEMIOLOGY.

The invasion of New South Wales by plague in 1921-22 exhibited some features of peculiar interest. Within a small compass it presented a very perfect picture, both epidemiologically and epizoologically, of a typical plague outbreak and, largely owing to its limited extent, its observation was able to be very thorough. The links in the chain of evidence illustrating the progress of the rat epizootic were fairly complete, and the connection between each human patient and the infected rat was, with few exceptions, established. Additionally, and this is an unusual feature of plague outbreaks, the very earliest beginnings of the epizootic were observed and traced with considerable certainty to the actual ship which was responsible for the introduction of the infection to Sydney from overseas. On the therapeutical side the outbreak witnessed the introduction and use of what appears to have proved an effective curative serum.

The outbreak in New South Wales lasted from 19th September, 1921, until 13th July, 1922, a period of nearly nine months. Sydney was the only locality affected. During the period in question 35 human beings were attacked, of whom 10, or 28·6 per cent., died. The number of plague infected rats found was 151. The first plague rat was got on 19th September, 1921, and the last on 13th July, 1922. The first human case occurred on 29th November, 1921, and the last on 9th June, 1922.

The control of the outbreak was throughout in the hands of the State Public Health Department. The personnel of the machinery of control consisted of (*a*) the administrative medical staff of the Department, the members of which possessed previous plague experience; (*b*) the Microbiological Laboratory of the Department, with its staff; (*c*) a highly competent staff of sanitary inspectors; and (*d*) a body of trained rat-catchers. For purposes of the epidemic the Municipal inspecting and rat-catching staffs of the City of Sydney operated under the control of the State Health Department, and are included in the above enumeration.

Ever since the plague outbreak of 1900-09 steady progress had been made in the permanent rat-proofing of wharves and business places along the water front and throughout the city, by means of concrete flooring and sheeting. Particular attention was given to produce stores, stables, and buildings where food was stored and sold. A rat intelligence staff was constantly maintained, not to exterminate rats, but to keep up a continuous nightly trapping of the dangerous area and to bring the trapped rats to the Microbiological laboratory for examination.

The 1921-22 outbreak consisted of a primary focus of infection and nine offshoot groups, most of them situated at considerable distances from the primary focus. The primary focus was situated in the business portion of the city, near the wharves of Darling Harbour, and it became infected by means of plague rats which reached it overseas from Queensland. In five of the secondary outbreaks the infection was definitely grouped round a produce store or a stable which had been supplied with fodder, &c., from the Darling Harbour wharves. The inference was that plague rats carried in the produce had infected each of these localities, and with one exception plague rats were found in every distinct area infected.

In the course of the outbreak the Department received great assistance in its onerous duties from several public bodies—more particularly from the City Council, the Harbour Trust, and some of the suburban Municipal

*Accounts of the eighth (1909) and ninth (1909) outbreaks were not published.

Municipal Councils, who furthered the efforts of the authorities considerably in the destruction of rats and (each within its own borders) in enforcing the rat-proofing of buildings. A Citizens' "Clean the City" campaign was inaugurated by the Lord Mayor of Sydney (Mr. W. P. McElhone), who was also instrumental in establishing a Block Association among the business men. The business portions of the city were divided into blocks, each under the control of an elected council, one of the most important duties of which was to create a strong public sentiment towards the destruction of rats in the area under its control. These Block Associations achieved much useful work, and were of no small assistance to the Department in its campaign of rat destruction.

The Commencement of the Epizootic.

The first intimation to this State that bubonic plague had once more invaded Australia was a telegram published in the Sydney morning papers of 15th September, 1921, which announced that a death from plague had occurred in Brisbane on 23rd August, 1921. On the same date a formal communication confirming the press announcement was received by my Department from the Department of Health of the Commonwealth.

No other developments occurred until 19th September, 1921. On that date the steamer *Wyreema* arrived from Brisbane in the early morning and, after examination by the Federal Quarantine authorities, was allowed to come alongside No. 2 A.U.S.N. Wharf and began discharging her cargo under supervision of a quarantine officer. In the afternoon six dead rats were found beneath the cargo in No. 4 hold of the vessel. The quarantine officer in charge immediately caused them to be brought to this Department, where, on bacteriological examination, one was found to be plague infected. The others had probably died of plague also, but were too putrid for examination.

The Federal Quarantine authorities were immediately informed, and the holds of the *Wyreema* were closed and fumigated by them. Early next morning the *Wyreema* was removed from the wharf and anchored in the stream under control of the Federal Quarantine Department. On 20th September a large number of rats found on board were sent to my Department for examination and eleven of them were found to have plague. All the rats sent from the *Wyreema* were of the black variety (*Rattus rattus*).

On 21st September, 1921, two black rats were found dead on the A.U.S.N. Wharf, near where the *Wyreema* had been tied up. On examination they were found to be plague infected.

On 22nd September, 1921, a grey rat (*Rattus norvegicus*), caught on the same wharf, proved on examination to be plague infected, and between that date and 6th October twelve more infected rats were found, either upon the same wharf or in an engineering workshop situated at the base of the wharf, during operations of cleansing and disinfecting which were carried out at the wharf throughout the period in question.

All the dead rats found in the process of cleansing this locality were recently dead. Only two of them were too decomposed for bacteriological examination and they were found towards the close of the cleansing operations. Such an absence of decomposed carcases is inconceivable in places where plague has been prevalent for an appreciable time among the rat population and indicates that plague had invaded the wharf contemporaneously or nearly so with the first discovery of plague rats.

Another important fact is that a particularly strict watch was always kept on this wharf, owing to its special susceptibility to plague invasion. Between 1st August and 20th September, 1921, twenty-seven rats had been caught there upon nineteen different dates. All of these rats were healthy. No plague rats were found upon the wharf until after the arrival of the *Wyreema*.

In order to follow more correctly the progress of the rat epizootic and to obtain a better grasp of the whole outbreak, it will be convenient to deal with it in ten groups or areas, which I have named the North Central (the primary focus), the South Central, the Paddington Nos. 1 and 2, the Woolloomooloo, the Alexandria, the Redfern, the Bunnerong, the Glebe, and the Pyrmont areas. Though these areas or groups are quite distinct upon the map, they have certain relations to one another, which will presently appear. This method of description involves a little overlapping in the time relation, which is, however, of no importance. The epizootic in each area, with its accompanying human infections, constitutes a group of facts complete in itself.

The Spread of Infection (Areas "A" to "J").

The sequence of events in the *North Central Area* ("A") was as follows:—Plague rats continued to be taken upon the A.U.S.N. wharf and one wharf adjoining it (Howard Smith's No. 1 wharf) until 6th October. After that date though intensive rat catching operations upon these wharves and the surrounding neighbourhood were continued without intermission, no more plague rats could be got until 5th December. On 3rd December a case of human plague (case No. 2, see Table II. on page) occurred on business premises at 102 Sussex-street, situated about 100 yards from the A.U.S.N. wharf, and on 5th December, a rat from the same building was ascertained to be plague infected. Between that date and 20th January, 1922, twenty additional plague rats were found on seven business places (mainly produce stores) in Sussex, Day, and Kent streets, all within 150 yards of the centre of the group. Again there was a lull, until 13th April, when five infected rats were obtained at 197A Sussex-street, a little distance south of the A.U.S.N. wharf, and from then until 13th July, an occasional infected rat was brought in by the rat-catchers. The total number of infected rats found in this area was fifty-six. Only one human infection occurred in the area.

The South Central infected *Area* ("B") is over a quarter of a mile distant in a southerly direction from the north-central area, and, although the district between the two areas was assiduously searched and trapped from the first beginnings of the outbreak, no plague rats were taken there. In contrast to the compactness of the northern area, the infected premises in this group are strung out in a straggling line, stretching east and west from Sussex-street to Bourke-street. This area yielded twenty-three plague rats from four premises (besides a considerable number of carcases presumably dead of plague, but too putrid for examination), together with seven infections (cases Nos. 1, 3, 4, 6, 19, 22 and 23) in human beings. The evidence as regards the localisation of the infection of one case, however, is presumptive rather than absolute (case No. 4).

Plague rats were first found in this area in a large produce store at 361 Sussex-street, on 1st November, by the City Council rat staff. Fifteen plague rats were obtained on these premises, but no human infection occurred.

occurred. The next door premises, however, yielded the first human patient of the outbreak—on 26th November, 1921 (case No. 1). Though no proved plague rats were discovered here, two or three carcases of rats, which were suspected of having died of plague, but were too putrid for examination, were found on the premises. They had been no doubt infected from next door.

The manner in which plague infection reached the rat population of No. 361 Sussex-street, could not be ascertained with certainty. Careful investigation failed to disclose any opportunities for the conveyance of rats from the A.U.S.N. wharf or the north-central area. It was considered not improbable that infection was introduced directly from Brisbane in cases of eggs which were regularly received by the firm occupying the premises, from the Brisbane branch of their business, in connection with which the first Queensland case of plague had occurred. On the other hand, one cannot entirely negative the possibility of the infection having been brought to the store from the A.U.S.N. wharf after the arrival of the *Wyreema*.

One of the human cases connected with this area was surrounded by circumstances of sufficient interest to warrant a detailed statement of the facts here.

On 9th February, 1922, a schoolgirl (J.L., Case No. 4), aged thirteen, died rather suddenly at a boarding school in Parramatta. She had been ailing since the afternoon of 5th February, but her illness did not at first appear to be serious. On 7th and 8th February, she became worse and vomiting set in. On the morning of the 9th the medical practitioner in attendance suspected plague, and communicated with the Department. Dr. Robert Dick, of the Health Department, visited Parramatta, but the girl was dead before he arrived. He made a *post-mortem* examination and the diagnosis of septicæmic plague was verified bacteriologically.

How had she been infected? As far as was known, Parramatta was entirely free from plague infection and remained so. A very careful search of the school buildings disclosed no evidence whatever of the presence of rats, and the girl had not been away from school since she returned there on 29th January, after the summer holidays. She had spent the holidays in question with an aunt at Brighton-le Sands. This latter district was also free from all suspicion of being infected and the aunt's premises were on inspection found to be free from rats. On 24th January, however, the girl had been to Sydney with her aunt and had visited several shops in the Liverpool-street block of the south-central infected area, and had in particular spent over an hour making purchases of underclothing in one large drapery establishment in the block. There must have been plague rats in the block on 24th January, when J.L. visited it, as, four days later, on 28th January, a human case of plague occurred in the block and several plague rats were taken there, including, at a later date, one in the actual drapery establishment visited by J.L.

It will be observed that a period of twelve days elapsed between the time at which the patient visited the infected area and the date of her attack. This is a long incubation period for plague, which does not as a rule exceed five days. The Indian Plague Commission, however, ascertained experimentally that a plague flea might remain infective for fifteen days after it had left its rat host. The possibility, therefore, cannot be overlooked of J.L. having picked up a rat flea in the course of her visits to shops in the infected area and having been bitten by it at a later date. Such an occurrence, though an evident possibility, is unusual and the source of infection in this case must still be regarded as obscure. After careful investigation, however, it is the only likely hypothesis which can be advanced.

The Paddington No. 1 Area ("*C.*")—On 18th February, 1922, the Medical Superintendent of the Royal Prince Alfred Hospital reported the case of J.A.R. (Case No. 5), a man aged seventeen, residing in Comber-street, Paddington, and employed in a produce store situated at 76 Oxford-street, a few yards from his residence, as one of plague. The patient was immediately removed by ambulance to the Coast Hospital, where the diagnosis was confirmed. The produce store was quarantined, and searched for rats. Two carcases were found, but both were too decomposed for bacteriological examination. There was, however, good reasons for believing that they had died of plague. A history of sick rats having been seen about the store was also obtained. When admitted to the Coast Hospital, J.A.R. was very ill and delirious, but a few days later he stated that he had seen dead rats in the basement of the store where he had been working a few days before his illness. Examination of the store disclosed numerous rat holes and abundant traces of rat infestation. On investigation it was ascertained that several loads of chaff and other produce had been brought to this store from a plague-infected establishment in Sussex-street (north-central area) between three weeks and a month before J.A.R. was attacked, and it seemed clear that plague rats or fleas must have been concealed in the produce and infected the rats in the Oxford-street store.

The area of Paddington in which this produce store is situated, was in a bad condition structurally. The buildings upon it facing Oxford-street are for the most part small combined shops and dwellings and at their rear is a closely packed mass of old, small terrace dwellings crowded between narrow lanes. In many cases the yards at the rear of these premises had been wholly or partially covered by stables and sheds of the roughest description, quite unsuitable for a modern city and affording abundant harbourage to rats, which was enhanced by considerable accumulations of rubbish. Similar harbourage was disclosed in most of the houses, which were generally in a bad state of repair. As a matter of fact, the whole area proved to be rat infested to a marked degree. It was clear that the opportunities for the spread of plague from the rats at the produce store were numerous and a strong staff of rat-catchers was turned into the area to search it, and, if possible, to clear it of rats. The search was rewarded by the discovery of plague rats on several of the immediately surrounding premises, including Nos. 72A, 80, 84, and 88 Oxford-street, and No. 5, West-street, while several carcases of rats, which were ascertained to have died of plague were picked up in the streets and lanes of the area.

Two other human cases of plague occurred in this area (Cases Nos. 7 and 8). Both the patients acquired infection at No. 84 Oxford-street, while the premises were in quarantine on account of a plague infected cat and a plague rat having been found there. One was the wife of the occupier and the other a young tradesman engaged in carrying out repairs to the premises enforced upon the owner by the Department. This young man's case is specially interesting from the fact that the incubation period of his attack could be very accurately fixed. He began work on these premises on the morning of 7th March, and continued there during that day. On the eighth he was not at the premises at all, being engaged at work in another

another district which was never attacked by plague. On the ninth he again returned to 84 Oxford-street, and worked there till 4.30 p.m., when he returned to his home at Mosman, and was taken ill with a headache and rigor at 9 p.m. He must have been infected on the seventh, between 10 a.m. and 5 p.m The incubation period in his case was therefore more than fifty-two hours and less than fifty-nine hours.

The Woolloomooloo Area (" *D* ").—The Woolloomooloo group of cases or sub-epidemic presents many interesting features. It centred round a livery stable, with dwelling attached, situated at 119 Dowling-street, in a residential district. On 22nd March, 1922, a motor-car driver (J.C., Case No. 9), a single man, residing in lodgings in Darlinghurst and employed in a motor garage in Castlereagh-street, died suddenly of plague in the Sydney Hospital before he could be removed to the Coast Hospital. Careful investigation led to the conclusion that he had not contracted infection either at his lodgings or the place of his employment and for a few days the Department was at a loss. At length, a minute inquiry into his movements during the week before his illness disclosed that on at least two occasions during that time he had spent the evening at 119 Dowling-street, Woolloomooloo, and that a young woman residing on the same premises had recently had an illness described as " slight " from which she was convalescent. She was visited by a medical officer of the Department and the opinion formed that she had undergone a mild attack of plague, from which she had scarcely recovered, as there was still an indurated and slightly enlarged glandular mass in the right groin. The diagnosis was subsequently confirmed serologically (E.S., Case No. 14). Inquiry elicited from the convalescent herself and from other inmates of the premises that rats had been dying in the livery stables for two or three weeks before E.S. became ill. The fact of the visits of the motor driver J.C. to the premises in the three or four days immediately preceding his illness was also established, and it became clear that he had contracted infection there.

On 28th March a little girl (M.W., Case No. 10) was found to be ill with plague at No. 115 Dowling-street, and it was ascertained that she had been a frequent visitor at No. 119 (two doors from her own residence) and had waited on Miss E.S. during the latter's illness. M.W. had a very severe attack of plague. The next day a stableman (R.R.) employed in the livery stable attached to No. 119 Dowling-street presented himself with an " abscess " in the groin, which he had had for some days and which had followed an illness accompanied by headache, shivering and vomiting. The illness, he said, had only lasted for one day. He was sent to the Coast Hospital as a plague suspect and later the diagnosis of plague was confirmed bacteriologically and serologically (Case No. 13). This case and that of E.S. are interesting as being the first " mild " cases of the outbreak. It will have been gathered that 4 cases of plague were traced to No. 119 Dowling-street, 3 of which occurred before any suspicions were directed to the premises. As soon as the premises became suspect they were quarantined, searched for rats, and disinfested. A number of rat carcases, all of them two or three weeks old and too far advanced in putrefaction for bacteriological examination, were found in the basement of the dwelling and the attached stables. They had evidently died of plague. The fodder used in the stables had been obtained from several firms in the infected area in Sussex-street, and had no doubt been the vehicle of infection to the premises. More definite information on this point was lacking. During the process of cleaning up and disinfesting the block of buildings in which No. 119 was situated, a mother and her little daughter, residing in Judge-street, in the same block as 119 Dowling-street, and at the rear of the latter, were both attacked by plague and both were very seriously ill (Cases Nos. 12 and 15). Altogether, 6 persons were attacked by plague in this area. Only 1 rat was obtained from the area which could be rigidly proved to have died of plague, but many rat carcases brought in were too old for useful bacteriological examination. There was ample proof forthcoming of an extensive and fatal epizootic among the rats of the area, which, under the circumstances, was in itself sufficient evidence of plague among them.

The Redfern (" *F* ") *and Bunnerong* (" *G* ") *Areas.*—These are grouped together because the epidemiological circumstances in the two areas resembled one another rather closely. In each locality a strictly limited outbreak of plague occurred in the immediate neighbourhood of a building—a produce store in the Redfern area and a stable in the Bunnerong area—which was used for the storage of fodder. In both cases the fodder had been obtained from business places in the infected area (North Central) on the shores of Darling Harbour. Subsequently to the occurrence of cases of human plague in each area, it was ascertained that heavy mortality had occurred among rats in the produce store and the stable in question, and in both cases, although the rat mortality had been observed by persons employed in or about the buildings, it had been attributed to the effects of poison, and had not been reported to the Department. Both establishments yielded rat carcases, which on examination were proved bacteriologically to have died of plague. In each case this took place after the occurrence of the first human case of plague. Three cases of human plague (Nos. 24, 31, and 35, including a father and son from one house) occurred in the Redfern area, and 5 cases (Nos. 25, 26, 28, 29, and 30), of which a mother and two children came from one house, in the Bunnerong area. Bunnerong is a locality situated on the northern shore of Botany Bay in the southern portion of the municipality of Randwick. The area attacked consisted of a small isolated group of four dwellings surrounding a wool-washing establishment with a stable attached. The immediate neighbourhood consists of open country covered with a low scrubby growth. The Redfern area, on the contrary, is in a very thickly built on neighbourhood in one of the most populous suburbs of Sydney.

The Alexandria Area (" *E* ") presents a different picture. Here the outbreak was more diffuse, and though the area yielded but 6 cases of human plague and 4 proved plague rats, infection must have been rather widespread, as dead rats partly dried up, or too advanced in decay for bacteriological diagnosis, were found on many premises in the area. The sanitary circumstances of the area are not good. Much of it is low-lying and swampy, and vegetable gardens owned and worked by Chinese cover a considerable proportion of the surface. The dwellings occupied by many of these people as well as those of not a few Europeans, were found to be unfit for human habitation, and of a nature calculated to give abundant harbourage to rats. A number of them were condemned and demolished by the action of this Department. Their continued existence was a disgrace to the local authority. Many noxious trade establishments are situated on the area, and stables often of a makeshift and dilapidated structure are fairly numerous. There were, in short, great facilities for rat infestation, which as a matter of fact, was found to be considerable.

The

The first human case from this area was that of a young man (No. 11) of no very definite occupation, who resided in a ruinous hut in a Chinese garden in Godfrey-street. He lived alone, and information as to his illness was difficult to obtain, but he was said to have been first attacked on 27th March, 1922. On the 30th of the same month he was found lying delirous and moribund in his hut. He was taken to the Coast Hospital and died of plague about two hours later. After his removal a survey of the hut disclosed a number of decomposing rat carcases, some of them under his bed. All were too putrid for bacteriological examination, but the circumstances indicated that they had died of plague. Of the 5 other cases from this area, 3 (Nos. 16, 17, and 20) occurred in one house distant about 10 chains from the dwelling of the first patient. The other 2 cases (Nos. 18 and 21) were furnished by more remote places in the area. Dead rats were found by the cleansing staff on or near each of the premises on which cases of human plague occurred.

The Glebe Area ("*H*").—Two persons residing in Darghan-street, Glebe, within ten doors of one another, were attacked by plague at about the same date (1st and 2nd May), under circumstances which are worthy of description (Cases 27 and 32). The persons attacked were both young men employed in different business places in George-street, City, in an area which was never proved to be plague infected. No plague rats were found in the neighbourhood of Darghan-street, or indeed in any part of the municipality of the Glebe, and although a very extensive search of the premises surrounding the homes of both patients in Darghan-street was made, no rat carcases were found by the departmental staffs. There were, however, a few small stables in the vicinity, and a certain degree of local rat infestation was established. A very interesting circumstance came to light at the dwelling occupied by one of the patients (Case No. 27). One of two pet guinea pigs kept on the premises became sick on the same day as the patient, and on its death two days later, it was brought to the bacteriological laboratory of this Department, where it was ascertained to have died of plague. A history was also elicited from the inmates of the house that a recently dead rat had been found in a shed on the premises about a fortnight before the patient was attacked, although no poison had ever been laid. On review of all the circumstances, it was judged probable that the infection in cases 27 and 32 was acquired at their dwellings, and the area was proclaimed as infected.

Paddington No. 2 Area ("*I*").—This area which is nearly three-quarters of a mile distant from the Paddington No. 1 Area, was invaded nearly two months later than the latter, and was considered to have been separately infected. It yielded two human cases (33 and 34) and five proved plague rats. The district is a residential one at the north-eastern end of the municipality of Paddington near a park (Hampden Park), a portion of which had for some years been used as a municipal refuse tip. The area is closely covered with small houses, and rats were found to be rather numerous, probably owing to the vicinity of the tip. A few small stables existed in the neighbourhood, which as a rule drew their fodder supplies from the Darling Harbour produce stores. It was surmised that infection reached the area through one of the stables in question, though it could not be ascertained which one was at fault.

The Pyrmont Area ("*J*").—No human cases occurred in relation to this area, but nine plague mice and one plague rat were obtained therefrom. The area is situated on the western shore of Darling Harbour immediately opposite the North Central Plague Area, but separated from the latter by the waters of an arm of Port Jackson. The plague infected rodents were found on the wharves of this neighbourhood or in buildings at the base of the wharves. Large quantities of wheat were stored upon the wharves at the time, and the whole locality was over-run with mice. It is judged that the rodents in this area must have become infected by direct extension from the South Central area, as a railway goods line extends round the head and along the whole western foreshore of Darling Harbour, and this would have afforded a free runway to rats and mice.

Table I showing Location of Plague-infected Areas at Sydney, New South Wales, 1921-22, and Number of Human Plague Cases and Infected Animals associated with each Area.

Infected Areas.	Dates.	Associated Human Cases.	Serial Number and Species of Infected Rats.					Other Infected Animals.
			Serial No.	Total Infected.	Species.			
					R. norvegicus.	*R. rattus.*	*M. musculus.*	
A. North Central, Period 1	19-9-21—6-10-21 ...	Case 2	1—29...	29	14	15	...	...
„ 2	5-12-21—20-1-22 ...	.....	45, 46, 48—52, 54—67	21	15	6	...	...
„ 3	13-4-22—13-7-22 ...	.....	96–100, 102, 105, 106, 111, 114, 116, 121 143–145, 147–151.	20	...	17	3	...
B. South Central ...	1-11-21—3-5-22 ...	Cases 1, 3, 4, 6...	30–44, 47, 68–74, 101, 113. 119,	26	4	21	1	...
C. Paddington, No. 1 ...	22-2-22—21-3-22 ...	Cases, 5, 7, 8 ...	75–79, 93, 94, 82–84, 86–89. 85 (cat). 92 (kitten).	14	13	...	1	2 cats.
D. Woolloomooloo ...	28-3-22	Cases 9, 10, 12, 13, 14, 15.	95, 146	2	2	...	...	...
E. Alexandria	26-4-22—3-5-22 ...	11, 16, 17, 18, 20, 21.	103, 104, 112, 115 ...	4	4	...	...	...
F. Redfern	5-5-22—22-5-22 ...	24, 31, 35 ...	117, 127, 131, 132 ...	4	4	...	...	...
G. Bunnerong	3-5-22—12-5-22 ...	25, 26, 28 ...	108, 109, 122 ...	3	1	2	...	...
H. Glebe	2-5-22—3-5-22 ...	27, 32	107 (guinea pig) ...	...	...	...	...	1 guinea pig (pet).
I. Paddington, No. 2 ...	29-5-22—15-6-22 ...	33, 34	133–140, 142 ...	9	9	...	...	...
J. Pyrmont	3-5-22—8-6-22 ...	.....	110, 120, 123–126, 128–130, 141.	10	...	1	9	...
Miscellaneous—six plague rats obtained from isolated localities outside above areas.	20-12-21; 24-2-22; 3-3-22; 15-4-22; 8-5-22.	.....	53, 80–81, 90–91, 118.	6	2	4	...	...

(See p. 44.)

Administrative Measures.

The problem of plague in the seaport towns of Australia cannot be regarded as a passing one. Communications with eastern ports, which are often infected by plague, have become so frequent and rapid that Australia, will, at any rate for many years to come, be liable to invasion; and the past experiences of both New South Wales and Queensland have demonstrated that quarantine measures are unable to secure our ports from invasion, without imposing upon commerce such stringent precautions as would seriously interfere with trade. It is possible that in the future an international agreement requiring the fumigation of all sea-going ships before loading, and their practically entire clearance of rats by this means may in time modify the risk; but those days are yet to come.

Omitting for this occasion the question of the introduction of plague from overseas, which, as coming under the control of the Federal Quarantine Department, may be considered outside the scope of this brief survey, the administrative control of plague may be considered from two aspects: those of preparation and of active defence. In both directions we are fortunate enough to be the inheritors of the code of fundamental principles first laid down by that masterly epidemiologist, Ashburton Thompson.

Plague is a disease of the rat which secondarily affects man, and is conveyed from rat to man by the flea. In that sentence is embodied the whole theory of plague prevention. The disease is not directly communicable from man to man, except in the case of that form known as pneumonic plague; which is rare in civilized communities. The truth of this general statement is illustrated by the fact that, during the whole of the nine years (1900-1909) in which plague was prevalent in Sydney, no hospital nurse or attendant contracted plague.

From the fundamental principle just laid down, it follows that the campaign against plague resolves itself into a campaign against the rat, which has now rightly come to be regarded as the worst enemy of mankind known among mammalian animals. He is so bold, so adaptable and so prolific that the task of exterminating him in any ordinary city is almost herculean in its magnitude; but there is little doubt that, by the proper construction of buildings, he will be entirely banished from the model cities of the future. In the campaign against the rat, biology has hitherto failed us. Science has long sought and is still seeking some disease which, while harmless to man, will exterminate rats, but the search has so far been fruitless. Many rat viruses have been put on the market, but they have failed everywhere, including Sydney, where they have been tried on a fairly large scale on at least three occasions. In view of the fact that plague itself, probably the most fatal disease known amongst rats, never succeeds in exterminating them in a given district, the outlook in this particular direction does not appear very hopeful.

Apart from the regular destruction of rats, which should continue at all times in every seaport, irrespective of the presence or absence of plague, there are only two specific anti-rat measures which need mentioning here as necessary during non-epidemic times. They are the rat-proofing of wharves and buildings and the maintenance of a detective rat-catching staff, whose duties are, not to exterminate rats, but to keep going a continuous nightly trapping of the area which in a seaport town is certain to be the first attacked, *i.e.*, the water front. This measure will usually give the authorities the very earliest warning of an invasion of plague.

A very careful watch upon the health of the Sydney rats has been maintained year by year by the Health Department, ever since the second outbreak of plague in the year 1903. Two intelligence staffs of rat-catchers have been constantly maintained in operation since 1st April of that year. One of these staffs has been employed directly by the Health Department to catch rats on the wharves and water frontages, the other staff has been employed by the City Council, and works throughout the whole of the city. Every rat caught by these two staffs is always labelled with the address of the premises on which it was found and is brought to the Microbiological Laboratory of the Health Department, where it is dissected and examined. Since 1903 over 363,000 rats have been caught by these staffs, and examined as I have indicated. Full records of these examinations are always kept (p. 122).

The rat-proofing of buildings and wharves is unquestionably the most important weapon in the anti-plague armoury. No city would ever be attacked by plague in which all the buildings were constructed on rat-proof principles, provided thereafter that ordinary care be taken to prevent rats from breeding in them. Unfortunately, the reconstruction of a city on rat-proof lines is a slow and tedious undertaking; and though a majority of the buildings in the business centre of Sydney between Darling Harbour and the line of the parks have been made rat-proof during the past twenty years, there remain too many which have not yet been brought up to date in this respect. As far as the wharves are concerned, the work done by the Harbour Trust during the same period has been very satisfactory. Over 6 miles of wharfages, including nearly the whole of those used by deep-sea and inter-State shipping have been faced with concrete sheeting, and practically all store-houses and other buildings on the wharves or abutting on them have been floored with the same material, and otherwise rendered as nearly as possible rat-proof. The City Council and some of the suburban councils have also been active in the direction of enforcing rat-proof construction in produce stores, stables and some other classes of buildings, specially liable to rat infestation; and, though several of the suburban councils have entirely failed to realize their duty in this direction, there is no doubt that Sydney is in a far safer position with respect to plague than it was in 1909, when the last outbreak ended. These structural improvements greatly facilitated the handling of the present outbreak and have been largely responsible for its limitation within very narrow bounds.

An anti-rat measure which we have found most valuable in Sydney is the protection of water supplies in buildings in such a manner that rats cannot obtain access to them. This measure only requires mentioning for its value to become at once apparent. Like most other animals rats must have water or they die. The grey rat, *Rattus norvegicus*, in particular, is a very thirsty animal and drinks often and copiously, particularly when his diet is restricted to the driest of foods, as must be the case in well constructed rat-proof produce stores and other places of business. Consequently if his supplies of water are cut off he either leaves the building or dies. In any rat infested building, one usually finds a well marked rat track running along the nearest girder to every water closet cistern, and the same statement may be predicated of an unprotected gully or sink under a water tap. The mere covering of all the water closet cisterns in a building with

with a sheet of plain galvanised iron has in our experience frequently led to the disappearance of rats from a building previously overrun by them. The protection of all water supplies in buildings used for business purposes in such a manner that rats cannot obtain access to them is now compulsory in Sydney, and it is being rigidly enforced.

As soon as the announcement of the invasion of Queensland by plague was made in September, 1921, the rat intelligence staffs were largely increased in personnel, and their operations were practically confined to the threatened area—the water front and that portion of the city situated between George-street and Darling Harbour—and certain portions of that area were worked with special intensity. As the epizootic extended the dispositions of these staffs were modified from time to time as requisite.

Wherever a plague rat was found or a case of human plague occurred, the premises on which the rat was found or which were adjudged to have been the source of infection for the patient, were quarantined and "disinfested." The "quarantining" was not very stringent in character: and simply consisted in closing up the premises so as to prevent the escape of rats, and forbidding access by the public until the process of disinfestation was complete. The removal of goods from the premises during the same period was also stopped. This process of disinfestation has for its object the destruction of rats and fleas and may take several days or a few hours, according to the method employed. Meanwhile, an area comprising several street blocks surrounding the infected premises was intensively searched, poisoned and trapped, for rats by the official staffs. There is no question of driving abroad or scattering the rats by these proceedings. Such a result might arise in the open country, but it cannot take place in a city, where the whole of the area treated is covered closely with well-constructed buildings.

Two methods of freeing from plague premises ascertained to be plague infected were used in Sydney. One of these was by means of fumigation with hydrocyanic acid gas. The other consisted in turning over all the stock and movable materials on the premises by the manual labour of a gang of workmen, and searching out the rats, which were destroyed as discovered. The most speedy, convenient and thorough of these methods is the former. The gas makes its way into rat holes and crannies, finds out the rats and destroys them promptly. It also enjoys the immense advantage of killing off the fleas which infest the premises. On every occasion on which it was employed, control captive rats or guinea-pigs were used to test the efficiency of the fumigation. Rats or guinea-pigs in cages were placed before fumigation among the produce or other goods, under conditions resembling as closely as possible those which would occur naturally. That is to say, the cages were placed deeply in cavities excavated in the mass of the material stored, and were then carefully enclosed by packed layers of the material. After the fumigation was completed, the cages were uncovered to ascertain if the rats were killed. In the earlier experimental fumigations, live fleas were also used in test tubes plugged with an inch of cotton wool. On each occasion both rats and fleas were all killed by the action of the gas. Unfortunately, fumigation with hydrocyanic acid gas is not always practicable, owing to its rapidly fatal effects upon human beings if inhaled. Buildings in which it is used must be well isolated from other buildings, either by construction or position. When it can be utilized, it is ideal for the purpose, and stores containing as much as 700,000 cubic feet of space have been quickly and thoroughly freed from rats and fleas by this means. In this process one gramme of cyanide of potash and one cubic centimetre of sulphuric acid are required for every cubic metre of space to be fumigated (*i.e.*, 10 ounces of cyanide and 10 fluid ounces of acid to every thousand cubic feet). The process is not to be relied on to kill weevils; but is rapidly fatal to fleas, bugs, and most other forms of insect life.

During the 1921-22 outbreak of plague the total number of buildings disinfested in Sydney by means of hydrocyanic acid gas was 77, with a total capacity of 5,362,000 cubic feet. In no instance was the process accompanied by injury to any human being. Small birds in cages were used in many cases to test the freedom of a building from gas before re-opening.

The other method of disinfesting a rat-infested building, by turning over all the contents, is much slower than that by fumigation. In a large produce store or warehouse it may take days or even weeks, as against, say, twelve hours for the fumigation method. The inferiority of this method as regards the destruction of possibly infected fleas is manifest; and is not entirely compensated by the careful spraying of floors and all surfaces with kerosene emulsion, which was always done before and during any clearing up operations in a plague-infected building.

Whichever method was used, the premises were not released from quarantine until all defects in the building were made good by the owner—rat holes filled up, basements concreted, and the premises put generally into a rat-proof condition.

Guinea-pig "sentinels" were regularly used in Sydney during the outbreak to ascertain whether buildings were free of plague fleas. When used for this purpose, they were placed in stores or buildings which were known to have been plague infected, and had been cleaned up and freed from rats. If plague fleas were still in the building they would find their way to the guinea-pig and infect him with plague; in such a case the building was again sprayed with kerosene emulsion, and retained in quarantine until sentinels remained in the building uninfected for forty-eight hours. It was not our practice to use sentinel guinea-pigs in buildings which had been "disinfested" with hydrocyanic acid gas, because this gas, when correctly used, not only destroys all rats, but also fleas, and therefore does away with all danger. Guinea-pig sentinels were also stationed in the buildings immediately surrounding one which had been ascertained to be plague infected; and if one of these sentinels became infected measures were taken to "disinfest" the building he was placed in, exactly as would be done if a plague rat had been found there.

There are three species of the rat tribe common in Sydney, and all of them are more or less concerned in the spread of plague,—the grey rat (*Rattus norvegicus*); the so-called black rat (*Rattus rattus*); and the common mouse (*Mus musculus*). The last named is the least dangerous of the three. The mouse appears to be, under natural conditions, relatively immune to plague, and is rarely found to be affected. During the epidemic under consideration, and during the plague years of 1900—1909, though numbers of mice from plague infected areas were examined, very few were found to be infected. The other two species of rats, the black and the grey, are almost equally dangerous. These two species do not intermingle freely. Often a rat-infested building will be found to be inhabited only by one species of rat. When they are both found in the same building, the black rat (*rattus*), who is pre-eminent as a climber, will generally be found upon the

the higher stories, while the grey rat will occupy the basement or ground floor. The so-called "bush rat," frequently found in the open country round Sydney, is generally the black rat (*rattus*) run wild. There are indigenous varieties of true bush rats in New South Wales, but they are not common near Sydney. Several of the Australian marsupials appear to be liable to plague, as was seen in 1902, when the disease invaded the Zoological Gardens. This fact and the remarkable increase of rats in the country districts since New South Wales has become a great wheat-growing country, make the question of plague suppression very much more urgent than it was twenty years ago. It would be a great disaster if plague were to become chronic among animals in the rural parts of this country, as it did in Manchuria, in California, and in Suffolk in England.

There are two or three problems connected with plague which have from time to time been put forward as difficult of solution and which may very briefly be discussed here.

The first of these is the seasonal prevalence of plague;—why is it always at its worst in the months of March and April in Australia, seeing that rats are present with us all through the year in practically unvarying numbers? The answer to this lies in the seasonal activities of the flea. There are several fleas found upon rats, but only two of them seem to have much importance as plague carriers. One of them is the plague flea of cold countries (*Ceratophyllus fasciatus*); the other, which concerns us most, is the plague flea of hot countries (*Xenopsylla cheopis*). This last flea is common in Sydney rats at certain times of the year, but is very susceptible to climatic influences, and soon dies off if the weather does not exactly suit it. It thrives best in a moist, warm, but not too hot temperature, and it has been found in the microbiological laboratory of this Department that the number of fleas per rat is greatest during the months of February and March, after which they rapidly decrease. The cold weather appears to be adverse to the existence of this flea, and soon after its numbers diminish plague begins to disappear.

In India very hot, dry weather is also found to be inimical to the same flea, and there plague epidemics tend to die away as soon as the mean daily temperature rises to 85 degrees F.

An observation which has puzzled a good many people is that while plague in Sydney spreads, as a rule, by continuity very slowly, moving steadily and slowly from building to building, and sometimes taking days or weeks to travel 100 yards, occasionally it will make a sudden leap of several hundred yards, or even a mile or more to a new area. The explanation of this is that among well constructed buildings in a large city, rats appear rarely to leave the building in which they happen to be so long as they have plenty of food and water available and provided their numbers do not increase excessively. Some writers on plague assume that when rats in any particular locality are attacked by disease or by the destructive onslaught of man, they exhibit a tendency to leave the locality and scatter in search of safer quarters, and this supposed tendency has been adduced as a reason for avoiding direct attack upon the rats in premises where rat plague is discovered. Our experience in Sydney is, however, opposed to this view, though it may be true of rats in open country districts. It would appear that plague is spread from warehouse to warehouse by the chance rat visitor, who travels rarely apparently in search of a mate or of water supplies, or through some accidental circumstance, and then only goes a few yards from home to the next building or the next but one. On the other hand, when plague crops up in a new centre situated some distance away from the locality where it was prevalent, infected rats or fleas carried by human agency, and probably nearly always in produce or fodder, are the usual vehicles of infection. Then a new focus is formed from which infection again resumes its slow progress from building to building, unless it is checked by energetic measures of rat destruction. It was in this manner that each of the several plague areas is believed to have been infected.

Another problem is connected with the discrepancy so frequently observed between the number of plague rats caught on any premises and the number of human beings who become infected on the same premises. It has been a common experience that on premises on which large numbers of plague rats are found there is often no human being attacked, or not more than one, while sometimes on premises on which no plague rats are taken, or perhaps one only, there have been two, three, and even four human cases.

The explanation of this apparent anomaly probably lies in the time at which the premises are discovered to have been invaded by plague. When the rat population of a building is first attacked by plague, as each rat succumbs to the disease, its fleas leave it and seek another rat host. If there are plenty of these available, the rat fleas seem not to attack human beings, but go by preference to their proper hosts, which, in turn, they infect with plague. Later on, when many rats have died off and few healthy ones are left, the rat fleas, in default of their natural hosts seek human beings, and infect them. If the building is discovered to be plague infected while it still contains many rats, immediate disinfestation may succeed in preventing any human infection. On the other hand, when the attack of a human being by plague has first drawn attention to a building, it has been found that the rats in it have nearly all died already, and though it may be surmised with considerable certainty that they have died of plague, this cannot be proved, owing to their carcases being far advanced in decomposition.

I do not propose here to discuss at length all the methods which may be employed for rat destruction, but I think it is not inopportune to mention shortly some of the best ways in which the public at large may rid themselves of the vermin.

One of the methods used by public health authorities, namely, fumigation by hydrocyanic acid gas, although probably the most effective method in buildings known, is too dangerous to human life to be used by anyone but experts. All methods of killing off rats by infecting them with diseases have hitherto proved to be failures, though they have been tried in most parts of the world. Rat destruction by sulphur fumes, though quite effective on board ship, has in Sydney proved a failure in buildings.

There remain the methods of killing rats by means of their natural enemies, dogs, cats and ferrets, and by trapping and poisoning. All of these methods may be freely and safely used by the public, and probably they are best used in combination. Both dogs and cats are very useful, but in either case it is necessary to be sure that the right animal is used. The dogs must be well trained and preferably of the smaller varieties. The cats must be good ratters, and not over-fed. I have known large produce stores kept entirely free from rats through the agency of half a dozen cats of a good ratting breed. But not every cat will face a full-sized grey rat. As to ferrets, they are not to my knowledge used in Sydney at all, but they are used a little in Newcastle (New South Wales) and largely in England, and they are most efficient rat hunters, as they are exceedingly keen and blood-thirsty, and can generally follow a rat anywhere.

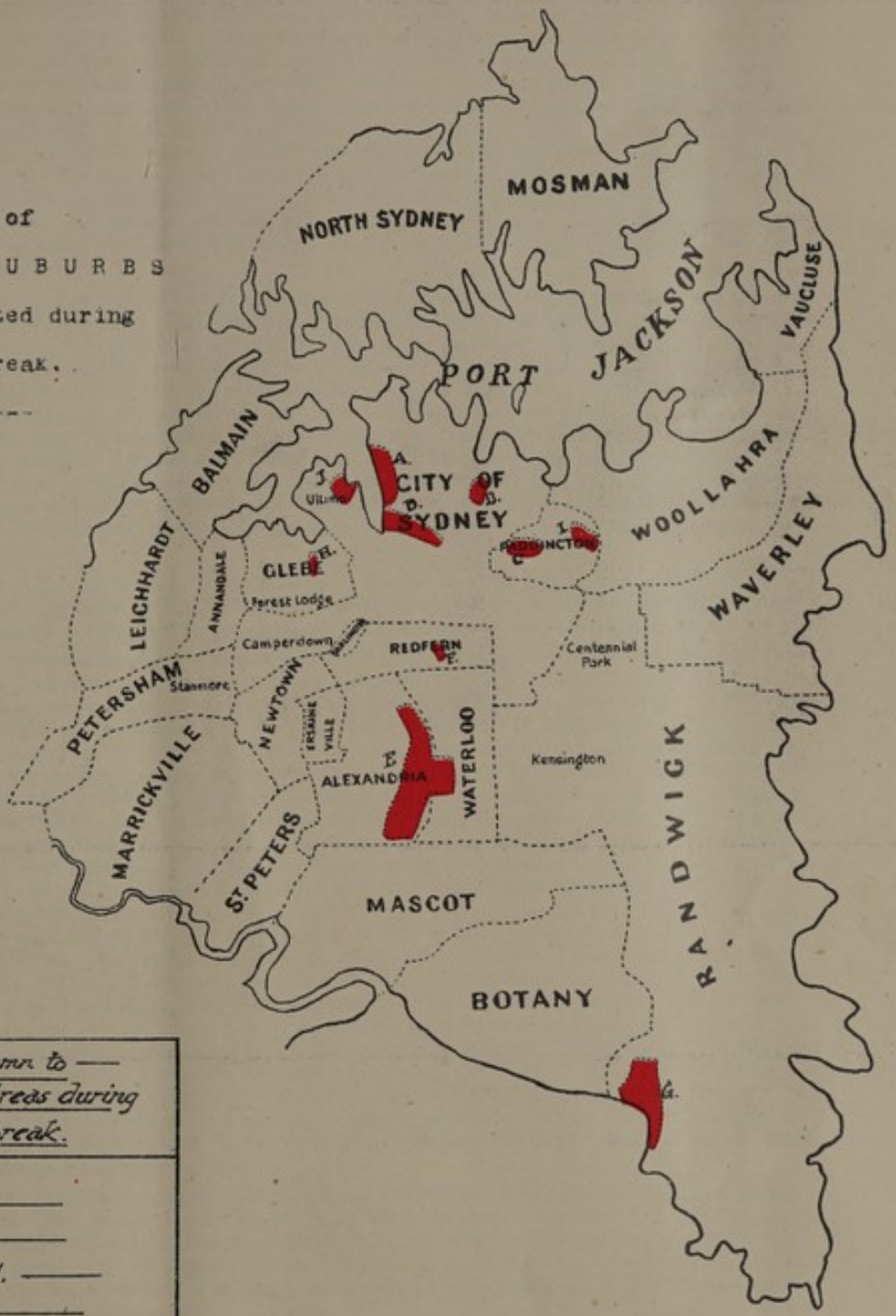
MAP

of portion of

SYDNEY and SUBURBS

shewing areas affected during

1921-22 Plague outbreak.



Reference Column to Plague Infected Areas during 1921–22 Outbreak.	
A	North Central. ———
B	South Central. ———
C.	Paddington No 1. ———
D.	Woolloomooloo. ———
E.	Alexandria. ———
F.	Redfern. ———
G.	Burnerong. ———
H.	Glebe. ———
I.	Paddington No 2. ———
J	Pyrmont. ———

W.H. Armstrong
1.8.23

Traps of the right sort and used with judgment are usually effective in clearing a building of rats. If the building is very heavily infested, as in the case of a barn or a badly neglected produce store, the best traps to use may be those which will catch several rats at one "take," such as one of the forms of the cage traps. But spring traps have the best reputation almost everywhere, especially in premises less heavily infested. In Sydney they are used almost exclusively. Their baiting is an important matter. In the London Zoo, which has a long experience of rat-catching methods, bread is found to be quite the most attractive bait, and dough made of flour is said to be the most attractive in India. Our own rat-catchers find it most effective to vary the bait and to provide generally something that differs from the common food found in the locality. For instance, they often find meat or bacon most effective in a produce store. Tallow and oatmeal are both good baits almost anywhere. The most important precaution to take is to fresh bait the traps daily. The traps should probably be handled as little as possible, but rat-catchers in Sydney do not take very elaborate precautions in this connection, and their success in trapping does not seem to have suffered thereby.

For general use, the best method of freeing premises from rats is probably by poison. The poison said to have been found most reliable in India is barium carbonate mixed with dough or tallow (Kunhardt and Chitre). We have used this poison a good deal in Sydney, and have found it satisfactory. Though both phosphorus and arsenic may be more reliable as rat poisons, they are not safe to use in places to which children or domestic animals can get access, whereas barium carbonate is relatively harmless to them in doses deadly to rats. Every bait should contain at least three grains of barium carbonate, which is sufficient to kill a grey rat. This chemical is tasteless, and does not appear to interfere with the consumption of the bait by the rat. Kunhardt and Chitre have shown by a very large number of experiments in India that the addition of any other food substance or condiment to the bait, such as sugar or salt or any flavouring substance such as oil of rhodium or aniseed actually diminished the number of the baits consumed by the rats. Phosphorus has been the poison most used in Sydney by the official staffs, and it has proved very satisfactory.

Squill, which is said to have been very successful in Europe as a rat poison, has been found to be almost useless in Sydney. In India, also in the hands of Kunhardt and Chitre, it proved to be of little value. It also has the disadvantage of being relatively expensive, while barium carbonate is a cheap poison.

The method of dealing with plague patients which was adopted in Sydney was simple and gave rise to no difficulties. Patients were treated at the Coast Hospital. At departmental head-quarters there were always available one or more medical officers with plague experience who were prepared to visit patients suspected of having plague and to consult with their medical attendants. If, after consultation, the case was considered to be suspicious of plague, an ambulance was at once sent to the patient's residence to convey him to the Coast Hospital, where, on his reception, he received a dose of anti-plague serum. If the patient was already in a public hospital when notified to the Department or if the medical attendant was definitely of opinion that the case was one of plague, the visit from a departmental consultant was often dispensed with on the grounds that it consumed time, and an ambulance was sent for the patient immediately. After the patient had been removed to hospital, the treatment of his residence and its inmates was the next consideration. In regard to the inmates, all that was done was to take their names and addresses and warn them to communicate immediately with departmental headquarters if they should become ill. If there were grounds for believing that the patient was infected at his residence or if on examination it was found to be rat infested, it was submitted to one or other of the processes of disinfestation previously described in this report. If, on the contrary, the infection was judged to have been taken elsewhere, the residence was merely sprayed with some disinfectant preparation. No further action was taken or necessary.

The anti-plague serum referred to was a local production, manufactured in Sydney by the Biological Institute of Australia and prepared under the superintendence of Dr. Burton Bradley, formerly Assistant Bacteriologist of this Department. The method of preparation I shall not refer to. It is described elsewhere by Dr. Ferguson, and the manner of its use and the results of its exhibition dealt with by Dr. Millard. It is sufficient to say here that it has been used upon every plague patient treated at the Coast Hospital in this outbreak, with four exceptions, and with very satisfactory results. The total number of plague cases during the outbreak has been thirty-five.

Thirty-one of the patients were removed to the Coast Hospital for treatment. Of the four cases in which admission to the Coast Hospital did not take place, three patients (Cases Nos. 4, 9, and 19), died suddenly or after a very short illness, and the diagnosis of plague was made after a *post mortem* examination. (In two cases however, plague had been suspected just before death by the medical practitioners in attendance on the patients). In the fourth case (No. 14) the disease was of a very mild type, and it was not found necessary to admit the patient to hospital.

The deaths due to plague in the outbreak numbered ten, equivalent to a mortality of 28·5 per cent. Seven of these deaths occurred in the Coast Hospital, so that the hospital mortality rate was equal to 22·6 per cent. of the admissions—or, if the patient (Case No. 11) who was admitted moribund and died two hours after admission be not included among the hospital cases—to 20 per cent. of the admissions. There appear to be good grounds for attributing the low mortality experienced to the use of the curative serum.

PART II.

REPORT ON THE TREATMENT OF PLAGUE PATIENTS AT THE COAST HOSPITAL.

(By R. J. MILLARD.)

Thirty-one cases were treated at the Coast Hospital during the outbreak. The first of these was admitted on 28th November, 1921, and died on 2nd December, 1921. He is, however, included in the subjoined tabular statement. The four patients not admitted to hospital are shown in italics.

This tabular statement shows in regard to each patient admitted to hospital the sex, age, date of onset, date of admission, type of disease with site of bubo (if any present), bacteriological diagnosis, serum treatment used, and the final result.

The sexes were evenly represented—16 males and 15 females.

Age.—Three patients were young children of 1 year, 2½ years, and 4 years. Two were aged 70 and 73. Two more were 60 and 61. The remainder were mostly young adults.

Type of Disease.—Inguino-femoral bubo in 22, axillary in 5, cervical in 1; three patients had septicæmic plague without a bubo.

Serum Treatment.—Anti-plague serum (made by the Biological Institute of Australia) was used in twenty-seven cases. The amount used per patient ranged from 40 c.c. to 300 c.c. But it is probable that the antitoxin value per c.c. of the serum was not always the same. The serum was being made when the outbreak began, and the first supplies were obtained from the horse before he was fully "worked up."

Results.—Six deaths in twenty-seven cases treated by serum appears at first a poor result. But an examination of the circumstances of the fatal cases shows that in several a fatal issue was inevitable. Thus, the first fatal case, P.M., was much addicted to alcohol, and was very ill on admission. J.C. (Case 11) was moribund on admission, and lived only 2½ hours. G.B. (Case 22) and M.Q. (Case 34) were both over 70 years, and of poor physique and resisting power, and M.D. (Case 35) was 60 years old.

In the patients that recovered the serum injected mostly had a most striking effect. The temperature fell and the condition of prostration changed to one of comparative *bien être*.

TABLE II—Human Plague Cases in Sydney (1921-22), showing Patients treated at the Coast Hospital with anti-plague serum (Biological Institute of Australia), and four patients who were not admitted to the Coast Hospital. The latter (Cases 4, 9, 14 and 19) are in italics.

Case No.	Patients initials.	Sex.	Age. Yrs.	Date of Onset of Illness.	Date of Admission to Hospital.	Site of Bubo.	Bacteriological Diagnosis.	Serum Treatment. Date of Injection.	Serum Treatment. Amount Injected.	Result.
									c.c.	
1	P.M.	M.	45	26-11-21	28-11-21	Left inguinal	Culture and inoculation.	1-12-21	50	Died, 2-12-21.
								2-12-21	50	
2	F.S.G.	M.	50	1-12-21	3-12-21	,,	,, ,,	3-12-21	50	Discharged cured, 23-1-22.
								4-12-21	50	
								5-12-21	50	
3	V.G.	F.	19	25-1-22	28-1-22	Right axillary	,, ,,	28-1-22	50	Discharged cured, 14-2-22.
								29-1-22	50	
4	*J.L.*	*F.*	*14*	*9-2-22*	.....	.....	.....	.....	.....	*Died at home, 9-2-22.*
5	J.R.	M.	18	15-2-22	18-2-22	Left femoral	Culture and inoculation.	18-2-22	100	Discharged cured, 24-4-22.
								19-2-22	100	
								20-2-22	50	
6	P.G.A.	M.	32	17-2-22	18-2-22	Right femoral	,, ,,	18-2-22	100	Discharged cured, 29-3-22.
7	J.L.	M.	17	9-3-22	11-3-22	Right inguinal	Culture	11-3-22	100	Discharged cured, 10-4-22.
8	E.F.	F.	27	10-3-22	11-3-22	Left inguinal	None made	11-3-22	100	Discharged cured, 2-4-22.
9	*J.C.*	*M.*	*30*	*22-3-22*	.....	.....	.....	.....	.....	*Died in Sydney Hospital, 22-3-22.*
10	M.W.	F.	9	26-3-22	27-3-22	Left inguinal	Culture	27-3-22	50	Discharged cured, 13-5-22.
								28-3-22	50	
								31-3-22	50	
11	J.C.	M.	22	28-3-22	30-3-22	,,	Culture and inoculation.	30-3-22	50	Died 30-3-22 (2½ hours after admission).
12	S.B.	F.	4	29-3-22	30-3-22	,,	Culture	30-3-22	50	Discharged cured, 23-4-22.
								1-4-22	50	
13	R. (or H.) R.	M.	50	21-3-22	29-3-22	Right inguinal	,,	No serum.		Cured, 12-5-22.
14	*F.S.*	*F.*	*43*	.....	.....	.....	.....	.....	.....	*Mild case: not admitted to Hospital.*
15	J.B.	F.	27	31-3-22	1-4-22	Right inguinal	Culture	1-4-22	100	Discharged cured, 23-4-22.
								2-4-22	50	
16	E.F.	F.	7	2-4-22	3-4-22	,,	None made	3-4-22	50	Discharged cured, 28-4-22.
17	A.D.	M.	23	6-4-22	8-4-22	Right femoral	Culture	8-4-22	100	Discharged cured, 4-5-22.
18	R.P.	M.	15	8-4-22	11-4-22	,,	,,	11-4-22	100	Discharged cured, 12-5-22.
								14-4-22	50	
19	*H.L.*	*M.*	*15*	.....	.....	.....	.....	.....	.....	*Died suddenly at home, 12-4-22.*
20	M.F.	F.	50	6-4-22	8-4-22	Septicæmic	Culture	No serum.		Discharged cured, 9-5-22.
21	A.E.	M.	42	16-4-22	17-4-22	Right femoral	,,	17-4-22	100	Died, 20-4-22.
								18-4-22	100	
								19-4-22	50	
22	G.B.	M.	73	19-4-22	21-4-22	Right axillary	,,	21-4-22	100	Died, 24-4-22.
23	E.O'D.	F.	21	24-4-22	27-4-22	Left inguinal	,,	27-4-22	100	Discharged cured, 28-5-22.
24	D.A.	M.	8	27-4-22	29-4-22	Right axillary	,,	29-4-22	50	Discharged cured, 2-6-22.
25	E.M.	F.	17	28-4-22	1-5-22	Right inguinal and plague carbuncle right side neck.	,,	2-5-22	100	Discharged cured, 31-5-22.
								3-5-22	100	
26	T.M.	F.	2½	30-4-22	1-5-22	Left axillary	,,	2-5-22	30	Discharged cured, 31-5-22.
								3-5-22	70	
27	A.N.	M.	16	2-5-22	2-5-22	Right femoral	,,	2-5-22	100	Discharged cured, 10-6-22.
								3-5-22	50	
28	E.E.M.	F.	1	30-4-22	30-4-22	Left cervical	,,	2-5-22	20	Discharged cured, 31-5-22.
								3-5-22	20	
29	L.P.	F.	33	25-4-22	30-4-22	Septicæmic	,,	4-5-22	100	Died, 12-5-22.
								5-5-22	100	
								6-5-22	100	
30	W.P.	M.	11	3-5-22	5-5-22	Right inguinal	,,	No serum.		Discharged cured, 18-5-22.
31	T.A.	M.	35	1-5-22	5-5-22	Septicæmic	,,	9-5-22	100	Discharged cured, 4-7-22.
								11-5-22	100	
32	R.S.	M.	27	1-5-22	4-5-22	Right axillary	None made	4-5-22	100	Discharged cured, 20-5-22.
33	J.W.	F.	61	12-5-22	17-5-22	Left inguinal	Culture	No serum.		Discharged cured, 6-6-22.
34	M.Q.	F.	70	31-5-22	4-6-22	Right femoral	,,	4-6-22	100	Died, 6-6-22.
								6-6-22	100	
35	M.D.	F.	60	6-6-22	9-6-22	Left inguinal	,,	9-6-22	100	Died, 10-6-22.

* N.B.—All serum was given by intramuscular injection.

Part III.—Report of the Microbiological Laboratory on Work in Connection with the Plague Outbreak of 1921–1922.

(By E. W. Ferguson.)

The following report is furnished on the work performed at the Microbiological Laboratory in connection with the plague outbreak of 1921–22.

In the main the report deals with the examination of rodents, which was carried out daily at this laboratory, and with the particulars of those found infected with plague. Material, smears and cultures were also examined from most of the human cases, and some investigations were made into the biochemical reactions of the bacilli isolated. An account is given of the preparation of the plague antiserum used in the treatment of the cases, this latter work was, however, not performed in the department, though subsequent to the outbreak the immunisation of the horses was continued by members of this staff.

Particulars are given of the fleas taken from rats collected during the plague period and the seasonal prevalence of the various species of fleas charted.

A limited amount of experimental work on rat poisons was carried out and is included in the report.

Before presenting the main body of the report, it might be as well to particularise the nature of the examinations that were made on rats and the evidence that was considered indicative of infection with *B. pestis*.

The ordinary routine examination consisted in opening the rat in the mid-ventral line and examining the liver and spleen; if no abnormality was found the body was then discarded and burnt.

If enlargement and congestion of liver and spleen were present, particularly if associated with a general congestion, hæmorrhage or necrotic areas in the spleen, smears were taken from liver and spleen and stained by strong carbol fuchsin, and differentiated with alcohol. The presence of typical bipolar bacilli was regarded as indicative though not absolute proof of plague. In the event of the rat being from known infected premises, this evidence was regarded as sufficient. Where the evidence was not considered satisfactory, or where the question of extension to a new area was involved, it was the practice to make cultures and inoculate guinea-pigs. Cultures were not always satisfactory, particularly if the animal had been dead some time and final proof rested on the guinea-pig inoculation. The appearances in the guinea-pigs that were regarded as diagnostic were a bloody œdema extending from the inoculation point, which was the site of a bubo, general congestion and hæmorrhages, particularly in lungs and intestines, enlarged and congested liver, enlarged spleen with necrotic areas, and hæmorrhagic congestion of the suprarenals, with recovery of bipolar bacilli in smears and cultures from the internal organs, inoculation point, and heart's blood.

Examination of Rodents.

The daily examination of rodents has been continued with two short breaks since 1900. Previous to the plague outbreak in September, 1921, a period of eleven years had elapsed since the last plague rat was found in May, 1910. Particulars of the examinations in this interval appear in the yearly reports of the laboratory (p. 122).

During the outbreak of 1921–22, a total of 32,677 rodents was examined from 19th September, 1921, to 15th July, 1922. Of this number, 148 rats and mice were found infected in the following numbers for the different species:—*Rattus norvegicus*, 67; *R. rattus*, 67; *Mus musculus*, 14.

In addition, 1 guinea-pig and 2 cats were found infected. The particulars of the infected animals are given below, grouped into the different plague areas, recognised as foci of the disease. The figures for the North Central area have further been subdivided according to dates, as there were decided breaks in the sequence of infected rats discovered in this area.

Particulars of Infected Animals.

North Central Area.—Period—19th September, 1921–6th October, 1921.

S.S. Wyreema.—Twelve infected rats (Nos. 1–12) were found on the vessel, in addition to several other rats, which were too putrid for examination. All the rats belonged to the one species—*Rattus rattus*.

As it is important that the diagnosis of the first infected rat found should be established beyond question, the following particulars are given *in extenso*.

Plague Rat, No. 1 (Rattus rattus).—Post mortem examination showed an enlarged and congested liver, and a somewhat enlarged spleen. Smears from the liver showed enormous numbers of gram negative bipolar bacilli, in shape and size strongly suggesting *B. pestis*. Cultures from the liver showed a pure culture of bacilli, which were morphologically *B. pestis*.

Animal Inoculation.—A guinea-pig was inoculated in the right groin with an emulsion from the liver on the 19th September. The animal died on the 22nd September. *Post mortem* showed hæmorrhagic swelling around glands of groin (bubo), general congestion of vessels with hæmorrhages in the abdomen, lungs and heart. The spleen and liver were enlarged. Smears from spleen, liver, inoculation point and heart's blood showed typical bipolar bacilli, and cultures showed a pure growth of *B. pestis*.

A.U.S.N. Wharf and Adjoining Premises.—Seventeen infected rats (Nos. 13–29) were found in this area, of which 3 were *R. rattus* and 14 *R. norvegicus*. Nine of the rats (3 *R. rattus*, 6 *R. norvegicus*) were found on the wharf, 6 in the A.U.S.N. workshops across Lime-street, and 2 from the Howard-Smith Wharf adjoining the A.U.S.N. The first two infected rats (Nos. 13–14) taken on the wharf were *R. rattus*, and may have been escapees from the *Wyreema*; they were picked up dead. The diagnosis was confirmed for one of them by guinea-pig inoculation. Plague rat No. 15, *R. norvegicus*, was obtained on the 22nd September, and was regarded as definite evidence of infection of the shore rats. The diagnosis on this rat was also confirmed by animal inoculation.

Period

Period—5th December, 1921–20th January, 1922.

102 *Sussex-street.*—One infected *R. norvegicus* (No. 45) was found on these premises on 5th December, 1921. The bacilli were present in somewhat scanty numbers in the spleen and liver, but were isolated in cultures. This rat was interesting, in view of the fact that although a *R. norvegicus*, it was taken on the top floor of the building.

99 *Sussex-street.*—Two infected rats (Nos. 46 and 48) were found on the 7th and 13th December respectively—both were *R. rattus*. The second rat was a young one, and the lesions were not marked, but the smears were typical.

52 *Day-street.*—Fourteen infected rats (Nos. 49–52, 54–63) were obtained from the 16th December to 3rd January, 1922. The species found is of interest in that the first ten rats belonged to *R. norvegicus* and the last four to *R. rattus*. This was the only occasion on which such a definite sequence was found.

118 *Sussex-street.*—One *R. norvegicus* (No. 64) found infected on 18th January, 1922.

263–277 *Kent-street.*—Three *R. norvegicus* (Nos. 65–67) found infected from 17th to 20th January, 1922. The diagnosis in the case of the first rat found on these premises was open to question as the lesions were not marked and the bacilli seen in smears, though suspicious, were scanty. Cultures were contaminated, but *B. pestis* was finally recovered from them. Two guinea-pigs were inoculated, 1 from the organs of the rat and another with the culture. Both animals died of plague, though the lesions were more marked in the guinea-pig inoculated with an emulsion from the organs of the rat.

Period.—13th April, 1922–13th July, 1922.

187A *Sussex-street.*—Between 13th April and 21st April five infected rats (Nos. 96–100) were found on these premises, all belonging to *R. rattus*.

69–71 *Day-street.*—One infected *R. rattus* (No. 102) on 21st April, 1922.

147 *Sussex-street.*—One infected mouse (*M. musculus*, No. 105) on 1st May, 1922.

194 *Sussex-street.*—One infected *R. rattus* (No. 106) on 27th April, 1922. The lesions on this rat were not marked, and the bacilli were scanty in smears, though typical.

139–41 *Sussex-street.*—One infected *R. rattus* (No. 111) on 3rd May, 1922. The rat was found dead in the rear of the premises.

City Council Carpenter's Shop, Day-street.—One infected *R. rattus* (No. 114) on 5th May, 1922.

123 *Sussex-street.*—One infected *R. rattus* (No. 116) on 6th May, 1922.

60 *Day-street.*—One infected mouse (*M. musculus*, No. 121) on 11th May, 1922.

239–241 *Sussex-street.*—Three infected *R. rattus* (Nos. 143–145) were discovered on 23rd and 24th June; the last (No. 145) was found dead after fumigation of the building.

Grafton Bond Stables.—One infected mouse (*M. musculus*, No. 147) on 8th July, 1922.

255A *Sussex-street.*—Four infected *R. rattus* (Nos. 148–151) on dates from 8th to 13th July. The rat found on the latter date was the last plague rat discovered in the outbreak.

Summary of Area—Plague rats found on sixteen premises:—

Rattus rattus infected	26
Rattus norvegicus infected	29
Mus. musculus infected	3
Total in area	59

The "Wyreema" rats (*R. rattus*, 12) are not included in above figures.

It may be noted that the species of rats infected differed according to the period, as is shown in the following table, which shows that *R. norvegicus* was more often infected in the first two periods, and *R. rattus* in the third.

	R. rattus.	*R. norvegicus.*
1st period (19–9–21—6–10–21)	3	14
2nd „ (5–12–21—20–1–22)	6	15
3rd „ (13–4–22—13–7–22)	17	...

South Central Area.

361 *Sussex-street.*—Plague-infected rats were discovered on these premises on 1st November, 1921; and from that date until 8th, a total of 15 rats (Nos. 30–44) were found infected. All belonged to the one species—*R. rattus*; 10 of them were found dead. The diagnosis in the case of the first rat discovered was confirmed by animal inoculation.

H. S. Whitehead, Factory-street.—An infected mouse (No. 47) was found on the premises on 7th December, 1921. The lesions were typical, but bacilli were scanty in the smears, and cultures were overgrown. Animal inoculation was not carried out. The diagnosis cannot, therefore, be regarded as confirmed.

97A *Liverpool-street.*—A dead *R. rattus* (No. 68) was picked up in the ladies' lavatory in the basement of this building on 31st January, 1922. The body was much decomposed, but as smears showed some suspicious organisms, a guinea-pig was inoculated, and died from plague.

Subsequently on the 6th and 7th February, five further infected rats were discovered on the premises, including 1 *R. norvegicus* (No. 69) and 4 *R. rattus* (Nos. 70–73.) Two of the rats were found on the top floor, the others in the basement. One (No. 69) was sick, and easily killed; the others were found dead.

Snow's, Pitt-street.—One infected *R. norvegicus* (No. 74) discovered on 21st February, 1922. The lesions on this rat were not marked, and only scanty bacilli were seen in smears from the spleen. The diagnosis was, however, confirmed by culture and animal inoculation.

554 *George-street.*—An infected *R. norvegicus* (No. 101) was brought in on 21st April, 1922, as having come from this address. Inquiry failed to substantiate the statement that it was taken on these premises, and the origin of the rat was not traced.

Coastal Farmers' Co-operative Society Poultry Market, Quay-street.—One *R. rattus* (No. 113) was found on 4th May, 1922.

Riverstone Meat Works, Hay-street.—A dead and partly eaten *R. norvegicus* (No. 119) was picked up on the railway line and proved to be infected with plague. The diagnosis was confirmed by animal inoculation.

Summary of Area.—26 infected rodents from seven premises, the species represented as follows:—*R. rattus*, 21; *R. norvegicus*, 4; *M. musculus*, 1. Two main periods occurred in which plague infected rats were obtained; in each instance odd infected animals were found at somewhat later dates.

(*a*) 1st November, 1921, to 8th November, 1921 (*R. rattus*, 15); 7th December, 1921 (*M. musculus*, 1).

(*b*) 31st January, 1922, to 21st February, 1922 (*R. rattus* 5, *R. norvegicus* 2); 3rd–21st April, 1922 (*R. rattus* 1, *R. norvegicus* 2).

Paddington No. 1 Area.

88 *Oxford-street.*—Four infected *R. norvegicus* (Nos. 75, 77–79) were obtained from these premises on dates from 22nd February, 1922, to 25th February, 1922.

On the 28th February a *R. norvegicus* (No. 87) was found dead at the rear of 88 Oxford-street; and on the 14th March a further *R. norvegicus* (No. 93) was found dead in the lane at the rear of the premises.

72A *Oxford-street.*—An infected mouse (No. 76) was found on 22nd February, 1922.

80 *Oxford-street.*—An infected *R. norvegicus* (No. 82) on 25th February, 1922.

5 *West-street.*—An infected *R. norvegicus* (No. 83) on 25th February, 1922.

84 *Oxford-street.*—An infected *R. norvegicus* (No. 84) was found on 28th February, 1922. On the same date a domestic cat (No. 85) was discovered to be infected. This animal had in addition to the typical *post mortem* lesions, marked pneumonia, and B. *pestis* was recovered from the lungs. A kitten (No. 92) died from plague on 14th March, 1922.

128 *Oxford-street.*—An infected *R. norvegicus* (No 86) was found in the paddock at the rear of these premises on 28th February, 1922.

Green's-road.—An infected *R. norvegicus* (No. 88) was found dead in Green's-road on 1st March, 1922.

Victoria Barracks.—An infected *R. norvegicus* (No. 89) was found dead on 14th March, 1922.

Shadforth-street.—On 21st March, 1922, a *R. norvegicus* (No. 94) was picked up dead in Shadforth-street. Decomposition had set in and the diagnosis was at first uncertain, but was confirmed by animal inoculation.

Summary of Area.—Sixteen infected animals were found from nine localities, including two streets in which the rats were picked up dead. All the rats belonged to *R. norvegicus*. One mouse and two cats were found infected. Infected animals were obtained in this area from 22nd February, 1922, to 21st March, 1922.

Woolloomooloo Area.

Stephen-street.—An infected *R. norvegicus* (No. 95) was found dead in the street on 28th March, 1922. This was the only infected rodent found in close proximity to the plague cases in this area.

Robinson-lane.—An infected *R. norvegicus* (No. 146) was found dead in the lane on 7th July, 1922. This rat is included in the Woolloomooloo area, though it is rather widely separated both in space and time from the plague cases, and might perhaps be better included in the miscellaneous section.

Summary of Area.—Two infected *R. norvegicus* from two localities.

Alexandria Area.

Tumeth and Sons, O'Riordan-street.—One *R. norvegicus* (No. 103) was taken on these premises on 26th April, 1922. A diagnosis of plague was made on the appearances found *post mortem*, but bipolar bacilli were scanty, though present in smears from liver and spleen. Cultures showed colonies resembling B. *pestis*, but contaminated with other organisms. A guinea-pig was inoculated from the tissues of the rat, but did not develop plague. The diagnosis of the disease in this rat is, therefore, open to question.

Kitchner and Sons, O'Riordan-street.—One *R. norvegicus* (No. 104) on 1st May, 1922, and another (No. 115) on 9th May, 1922, were found infected.

Queen's-street Tip, Alexandria.—One *R. norvegicus* (No. 112) on 3rd May, 1922.

Summary of Area.—Four infected *R. norvegicus* from three localities.

Bunnerong Area.

Caretaker's Cottage, Wool Scouring Works.—Infected rats were found dead on the premises on the 3rd May, 1922, and 12th May, 1922. Two (Nos. 108 and 122) were *R. rattus* and one (No. 109) was *R. norvegicus*. The occurrence of *R. rattus* in this area is interesting, as from the suburbs generally only *R. norvegicus* was obtained. *R. rattus* is, however, commonly found in the bush around Sydney and the Wool Scouring Works are situated near unoccupied bush land.

Glebe Area.

58 *Darghan-street, Glebe.*—A guinea-pig (No. 107) was found dead on 3rd May, 1922, and proved to be infected with plague. A second guinea-pig was brought in to this laboratory and kept under observation, but did not develop plague.

Redfern Area.

Spearman's Stables, Elizabeth-street, Redfern.—One *R. norvegicus* (No. 117) was found infected on 5th May, 1922.

73 *Elizabeth-street.*—Three *R. norvegicus* (Nos. 127 and 131–132) were found infected on 17th May, 1922, and 22nd May, 1922, respectively.

Summary of Area.—Four infected *R. norvegicus* from two premises.

Paddington No. 2 Area.

Soudan-lane.—Four infected *R. norvegicus* (Nos. 133–136) were found dead in the lane on 29th May, 1922, and 30th May, 1922.

Cecil House, Cecil-street.—One infected *R. norvegicus* (No. 137) was found dead in lavatory, 30th May, 1922.

Foxforth, Cecil-street.—One *R. norvegicus* (No. 138) was found dead in front of these premises, 6th June, 1922.

Cecil Cottage, Cecil-street.—One *R. norvegicus* (No. 139) was found dead on 6th June, 1922, and one (No. 140) on 7th June, 1922.

No. 1 *Soudan-street.*—One *R. norvegicus* (No. 142) was found dead on 15th June, 1922.

Summary of Area.—Nine infected *R. norvegicus* from five localities.

Pyrmont Area.

Gillespie's Flour Mills, Union-street.—One infected mouse (No. 110) on 3rd May, 1922. The diagnosis was not confirmed by animal inoculation, but the liver and spleen was definitely enlarged and contained typical, though scanty, bipolar bacilli. Cultures were overgrown.

Darling Harbour Wheat Berths, No. 10 *Berth.*—Five mice (Nos. 120, 123, 125, 126, 128) at varying dates from 9th May, 1922, to 18th May, 1922, and one *R. rattus* (No. 124) on 13th May, 1922, were diagnosed as plague infected. Four of the mice were found dead.

No. 12–13 *Berths.*—Two mice (Nos. 129–130) on 18th May, 1922; one mouse (No. 141) on 8th June, 1922.

The diagnosis of the mice as plague infected is open to question; in all the lesions were strongly suggestive of plague, but bipolar bacilli were only scantily present in smears from the spleen. In one instance (No. 141) animal inoculation was carried out, but the guinea-pig, though sick, did not die of plague. As no other mice were found no opportunity occurred later of further testing the diagnosis.

Summary of Area.—One *R. rattus* and nine mice from two localities, between 3rd May, 1922, and 8th June, 1922. Infection of this area probably took place by direct extension from the South Central Area.

Miscellaneous.

Under this heading are grouped plague rats obtained from isolated localities beyond the recognised areas, and also rats in which there is strong suspicion that they had been deliberately placed in the situation where they were found.

Plague Rat No. 53.—*R. rattus* picked up dead on 20th December, 1921, on landing outside animal *post mortem* room in the Microbiological Laboratory, Department of Public Health. There is strong reason to think that this rat had been thrown down in this situation, as officers had passed over the place shortly before, and could not have missed finding it.

Plague Rat No. 80.—Langdon and Langdon, Timber Works, Rozelle Bay, Glebe. This rat (*R. norvegicus*) on *post mortem* showed lesions suggestive of plague, the liver and spleen being enlarged and congested. Smears showed scanty bipolar bacilli, but cultures were overgrown.

A guinea-pig inoculated with fluid from liver and spleen died the following morning from another infection.

Plague Rat No. 81.—*R. rattus*, from Langdon and Langdon, found dead. The body was decomposed, but smears from liver and spleen showed numerous bipolar bacilli. Cultures were also in this case overgrown by *B. proteus*. A guinea-pig was inoculated, but did not develop plague.

The diagnosis in the case of these two rats cannot be regarded as proven.

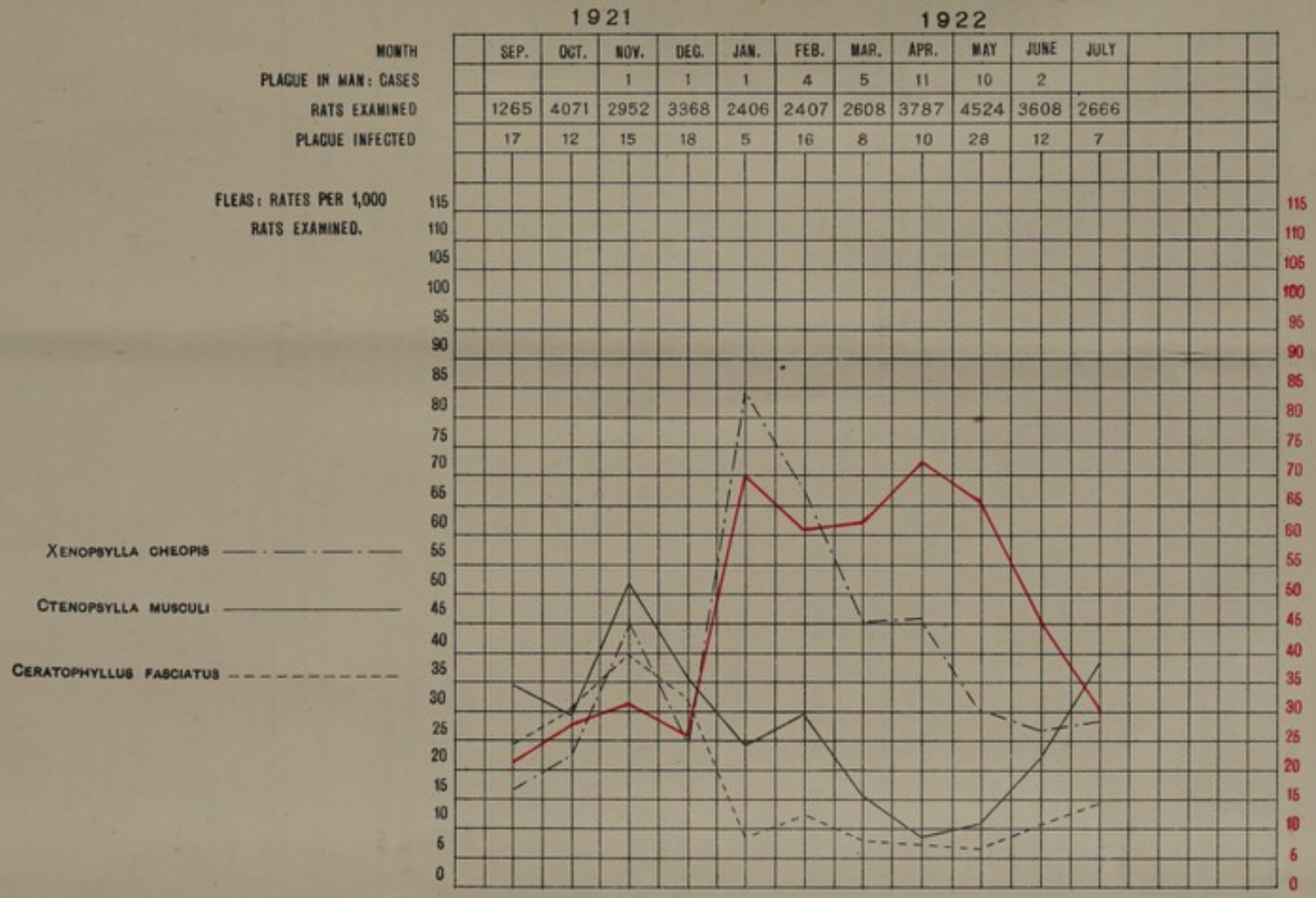
Plague Rats, Nos. 90–91.—On 3rd March, 1922, two plague-infected rats (*R. rattus*) were picked up under the end of Pyrmont Bridge. The rats had evidently been thrown there, as they were found wrapped up in paper. Their origin was not traced.

Plague Rat, No. 118.—An infected *R. norvegicus* was obtained from the Civic Club, Pitt-street. The premises are not in any of the recognised plague areas and no other infected rats were found in the neighbourhood.

TABLE III.—Showing the number and species of Rats examined and the number and percentage of each species found infected during the Plague Period, September, 1921–July, 1922.

Month.	No. and species of rats examined, showing % of each species.							No. and species of infected rats, showing % of each species infected.						
	R. rattus.		*R. norvegicus.*		*M. musculus.*		Total.	*R. rattus.*		*R. norvegicus.*		*M. musculus.*		Total.
	Gross.	Per cent.	Gross.	Per cent.	Gross.	Per cent.		Gross.	Per cent.	Gross.	Per cent.	Gross.	Per cent.	
1921.														
September	455	35·46	810	63·13	18	1·40	1,283	2	11·76	15	88·24	...	...	17
October	1,437	33·32	2,634	61·08	241	5·59	4,312	11	91·67	1	8·33	...	...	12
November	1,063	33·25	1,889	59·09	245	7·66	3,197	...	...	15	100	...	...	15
December	1,000	27·48	2,368	65·07	271	7·45	3,639	11	61·11	6	33,33	1	5·56	18
1922.														
January	649	26·97	1,588	66·00	169	7·02	2,406	4	80	1	20	...	...	5
February	811	33·69	1,338	55·59	258	10·72	2,407	9	56.25	6	37·5	1	6·25	16
March	1,093	41·91	1,183	45·36	332	12·73	2,608	6	75	2	25	...	...	8
April	1,508	39·82	1,478	39·03	801	21·15	3,787	4	40	6	60	...	...	10
May	1,280	28·29	1,386	30·64	1,858	41·07	4,524	10	35·71	8	28·57	10	35·71	28
June	674	18·68	915	25·36	2,019	55·96	3,608	9	75	2	16·67	1	8·33	12
July	525	19·69	1,060	39·76	1,081	40·55	2,666	1	14,28	5	71·43	1	14·28	7
Total	10,495	30·48	16,649	48·34	7,293	21·18	34,437	67	45·27	67	45·27	14	9·46	148

Graph shewing the three principal species of Fleas collected during the Plague period, September, 1921 - July, 1922.
The percentage of Xenopsylla Cheopis to total Fleas examined is also shewn, in Red.



Fleas from Rodents.

The collection and identification of fleas from rats proceeds as a routine measure in conjunction with the daily examination of rats, and the results are tabulated annually in the laboratory report. It has been thought advisable to collect together the data in regard to the flea prevalence during the plague period from 1st September, 1921, to 31st July, 1922.

Three species of fleas occur commonly on rats caught in Sydney—*Xenopsylla cheopis, Ctenopsylla musculi, and Ceratophyllus fasciatus.*

The figures collected over a period of fourteen years show that these fleas are present in the following relative proportions :—*X. cheopis*, 47·7 per cent.; *C. musculi*, 34·4 per cent.; *C. fasciatus*, 17·7 per cent.

These percentages are based on the total number of specimens of these species collected during the period, the totals for the three species being as follows :—*X. cheopis*, 7,176; *C. musculi*, 5,179; *C. fasciatus*, 2,671. The three or four other species of fleas that occasionally occur on rats are not considered here. The prevalence of the rat fleas varies with different seasonal periods, and this seasonal variation, as shown by the rate per 1,000 rats, differs in the three species. For *X. cheopis*, as shown by the charts published annually in the laboratory report, the incidence reaches its maximum about February, while the maximum incidence for *C. musculi* is generally about September.

The attached chart (p. 45) shows the seasonal variation for the three species during the plague period, *i.e.*, from 1st September, 1921, to 31st July, 1922.

In June and July, 1921, there occurred an unusual rise in the rate per 1,000 for both *C. musculi* and *X. cheopis*, followed by a drop in August and September. A slight rise in November is to be noticed for all three species, followed by a drop in December, from which, however, the curve for *X. cheopis* shows a sudden rise, reaching its maximum in January. Thereafter, there is a gradual fall to the end of the plague period.

The preponderance of *X. cheopis* over the other species during the latter half (January to July) of the plague period is also shown by the relative percentages of the three species to the total number of fleas examined each month. This percentage has been worked out for each species, and is shown in the accompanying table. The percentage for *X. cheopis* is also depicted in red on the chart, and the correspondence of the high proportion of *X. cheopis* relative to the other species, with the incidence of cases, is well shown.

It has been commonly considered that *X. cheopis* is more often found on *R. rattus* than on *R. norvegicus*, the figures for the species of fleas found on the two species of rats have therefore been worked out for the year 1922 :—

	X. cheopis.	*C. musculi.*	*C. fasciatus.*	Total.
R. rattus	366 (=33·4%)	449 (=40·5%)	292 (=26·5%)	1,107
R. norvegicus	246 (=31·2%)	331 (=42%)	211 (=26·4%)	788

A preference of any one species of flea for a particular species of rat as host is not shown, the variations between the percentages being so slight as to be well covered by the margin of error that must exist in considering such comparative small groups of figures. The percentages are of the various species of fleas to the total number of fleas collected from each species of rat.

A similar analysis was made by Professor Cleland in his presidential address to the Royal Society of New South Wales in 1918. His figures are based on the fleas caught from rats during the non-plague period, 1911 to 1917. The percentages were not given by Professor Cleland, but have been worked out and are presented below :—

	X. cheopis.	*C. musculi.*	*C. fasciatus.*	Total.
R. rattus	1,530 (=47·8%)	1,209 (=37·8%)	457 (=14·5%)	3,196
R. norvegicus	1,161 (=54·6%)	688 (=32·4%)	274 (=12·9%)	2,123

While these figures differ somewhat from those given for 1922, they support the conclusion quoted above. These percentages are also of interest for comparison with those given previously, and based on the rat flea returns for a somewhat longer period.

Table IV.—Showing in months number and species of Fleas collected and percentage of each species found during the Plague Period, September, 1921–July, 1922.

1921-22. Month.	Cases in Human Beings.	Number of Rats Examined.	Number of Rats found Infected.	Number and species of Fleas collected from Rats examined.												Total Fleas Collected.
				Xenopsylla cheopis.		*Ctenopsylla musculi.*		*Ceratophyllus fasciatus.*		*Ctenocephalus canis or felis.*		*Pulex Irritans.*		*Echidnophaga murraccobii.*		
				Gross.	Per centum.	Gross.	Per centum.	Gross.	Per centum.	Gross.	Per centum.	Gross.	Per centum.	Gross.	Per centum.	
September ...	...	1,265	17	21	21·88	44	45·83	31	32·29	...	...	...	...	...	...	96
October ...	...	4,071	12	90	27·27	119	35·06	121	35·67	...	...	...	...	...	...	330
November ...	1	2,952	15	134	32·06	154	36·84	119	28·47	11	2·63	...	...	...	...	418
December ...	1	3,368	18	82	25·71	121	37·93	109	34·16	5	1·57	2	·63	...	...	319
January ...	1	2,406	5	205	69·73	58	19·73	20	6·80	8	2·72	3	1·02	...	...	294
February ...	4	2,407	16	166	61·25	72	26·57	30	11·07	3	1·11	...	...	...	...	271
March ...	5	2,608	8	119	63·64	43	22·99	21	11·23	4	2·14	...	...	...	...	187
April ...	11	3,787	10	174	72·5	33	13·75	29	12·08	3	1·25	1	·42	...	...	240
May ...	10	4,524	28	162	65·59	52	21·05	33	13·36	...	...	...	...	...	...	247
June ...	2	3,608	12	98	45·16	79	36·40	39	17·08	1	·46	...	...	...	...	217
July ...	...	2,666	7	75	30·61	101	41·23	64	26·12	4	1·63	...	...	1	·41	245

The Examination of Material from Plague Cases.

The following account deals with the examinations made at this laboratory of material from the cases of plague:—As a rule suspected cases of plague were sent to the Coast Hospital, and the necessary smears and cultures were made there. In a few cases smears for diagnosis were taken in this laboratory, or material from post mortems was examined here. Also in most of the cases material was received from the Coast Hospital for confirmation or for special purposes.

Case 1.—(P.M.) Smears and cultures from the bubo were examined and were positive. Two guinea-pigs were inoculated with material aspirated from the bubo; both died with the lesions of plague, and *B. pestis* was recovered in culture.

Case 2.—(F.G.) Smears and cultures from the bubo showed *B. pestis*. This patient was admitted to the Coast Hospital on 5th December, 1921. On 19th December, 1921, two small necrotic glands were discharged from the suppurating bubo, and were forwarded for examination. Smears and cultures showed only secondary pyogenic organisms (Staphylococci and B. proteus), no *B. pestis* being found. A guinea-pig inoculated from the gland did not develop plague.

Case 3.—(V.G.) A culture from the bubo was received from the Coast Hospital. This was inoculated into a guinea-pig, which died of plague.

Later cultures were obtained from phlectenulæ on the right and left sides of the patient. Both were apparently cultures of *B. pestis*. The culture from the left side was injected into a guinea-pig, which died of plague.

Case 4.—(J.L.) Specimens were received from the post mortem. Smears and cultures from the bubo and spleen showed typical *B. pestis*. A guinea-pig inoculated with material from the bubo died of plague.

Case 5.—(J.R.) A culture was received from the Coast Hospital. *B. pestis* present.

Case 6.—(A.) Cultures were received from the Coast Hospital. *B. pestis* present.

Case 7.—(J.L.) Cultures received from Coast Hospital. *B. pestis* present.

Case 8.—(E.F.) Blood received for agglutination test (*vide infra*).

Case 9.—(J.C.) Smears were received from Sydney Hospital, taken shortly before death, and showed numerous bipolar bacilli. A post mortem was done at Sydney Hospital, and a large femoral bubo was found involving also the inguinal and lumber glands. Smears from the bubo and spleen showed numerous plague bacilli, and these were grown in culture from the bubo, spleen and heart's blood. A guinea-pig inoculated from the bubo died of plague.

Case 10.—(M.W.) Culture from left inguinal bubo received from Coast Hospital. *B. pestis* present.

Case 11.—(J.C.) Smears and cultures from the bubo showed *B. pestis*. A guinea-pig inoculated from bubo died from plague.

Case 12.—(S.B.) Cultures from bubo received from Coast Hospital. *B. pestis* present.

Case 13.—(H.R.) Cultures received from Coast Hospital were inoculated into a guinea-pig. The animal died eight days later from infection with B. gärtner; fairly numerous bipolar bacilli were present in the bubo present at site of inoculation, but could not be demonstrated in the internal organs. Another guinea-pig was inoculated directly from the patient, but did not develop plague. The results are of interest as the case was comparatively mild, there being little systemic disturbance, though a large bubo was present. The bacilli appeared typical except that they were apparently attenuated as shown by the animal experiments. Proof that the case was one of plague was furnished by the biochemical reactions of the bacilli isolated from the bubo, and by the agglutination test with the patient's blood.

Case 14.—(E.S.) Blood from this case was received for agglutination (*vide infra*).

Case 15.—(Mrs. B.) Cultures received from Coast Hospital. *B. pestis* present.

Case 16.—(E.F.) A guinea-pig was inoculated at the Coast Hospital with material from the bubo, but did not develop plague.

Case 17.—(A.D.) Cultures received from Coast Hospital. *B. pestis* present.

Case 18.—(H.J.L.) Material was obtained from the autopsy. Smears from spleen and heart's blood were positive. A guinea-pig was inoculated with material from the spleen and died from plague.

Case 19.—(R.P.) Cultures received from Coast Hospital. *B. pestis* present.

Case 20.—(A.E.) Cultures received from Coast Hospital. *B. pestis* present.

Case 21.—(Mrs. F.) Cultures received from Coast Hospital. *B. pestis* present.

Case 22.—(G.B.) Cultures received from Coast Hospital. *B. pestis* present.

Case 23.—(E.D.) Cultures received from Coast Hospital. *B. pestis* present.

Case 24.—(D.A.) Cultures from the bubo were received from the Coast Hospital. Colonies of *B. pestis* were present in one out of three culture tubes. A guinea-pig inoculated at the Coast Hospital did not develop plague.

Case 25.—(Mrs. E.M.) *B. pestis* was present in cultures from the bubo, and also in cultures from a carbuncle on the neck.

Case 26.—(T.M.) Cultures received from Coast Hospital. *B. pestis* present.

Case 27.—(E.N.) Cultures received from Coast Hospital. *B. pestis* present.

Case 28.—(E.M.) Cultures received from Coast Hospital. *B. pestis* present.

Case 29.—(B.P.) *B. pestis* was present in cultures from a pustule on forehead and from the blood stream.

Case 30.—(W.P.) Cultures received from Coast Hospital. *B. pestis* present.

Case 31.—(T.A.) *B. pestis* was present in a culture from a pustule on right forearm, and also in a culture from the blood.

Case 32.—(R.S.) Blood received for agglutination test (*vide infra.*)

Case 33.—(J.W.) Cultures received from Coast Hospital. *B. pestis* present.

Case 34.—(M.Q.) Cultures received from Coast Hospital. *B. pestis* present.

Case 35.—(M.D.) No material received.

Agglutination Reactions.

The agglutination reaction was carried out with the blood of a few of the cases. The microscopic method was used in dilutions of the sera 1/10, 1/20 and 1/40. The readings were taken at varying times. The results on the whole were unsatisfactory, but confirmatory evidence was secured in one or two cases where the diagnosis had not been confirmed by bacteriological examination.

Case 5.—(J.R.) Agglutination in 1/10 dilution in 4½ hours.

Case 7.—(J.L.) Agglutination in 1/10 dilution in 1 hour, in 1/40 dilution in 3½ hours.

Case 8.—(E.F.) No agglutination in 1/10 dilution after 3½ hours.

Case 10.—(M.W.) No agglutination in 1/10 solution after 3½ hours.

Case 13.—(H.R.) Agglutination in 1/10 dilution in 10 minutes, in 1/20 dilution in 3 hours.

Case 14.—(E.S.) Agglutination in 1/10 dilution in 3½ hours.

Case 32.—(R.S.) No agglutination in 1/10 dilution after 3 hours.

Controls from three other sources, not plague, showed no agglutination. The serum from a relative of two of the cases (Cases 24 and 31), living in the same house, was also tested. The person was a patient at the Coast Hospital suffering from typhoid fever, and her serum agglutinated *B. pestis* in a dilution of 1/10 in 1 hour, and of 1/20 in 2-3 hours.

Biochemical Reactions of Plague Bacilli.

Various cultures of *B. pestis* from both human cases and rats were subcultured on different carbohydrate media—the so-called sugars—to ascertain whether constant reactions were obtained in conformity with the results of previous workers on the subject. McConkey has shown (*Journ. of Hygiene*, vol. 5, 1905, Tab. B., p. 350) that *B. pestis* produces acid but no gas in glucose, lævulose, galactose, maltose, mannitol, and dextrin, and no change in lactose, cane sugar, and dulcitol. This list of media was extended by us, and the following reactions conforming to those of McConkey, were obtained :—

Glucose.	Mannitol.	Dulcitol	Lactose.	Saccharose.	Maltose.	Dextrine.	Galactose.	Inulin.	Amygdalin.	Salicine	Arabinose.	Raffinose.	Sorbitol.	Erythritol.	Laevulose	Adonitol.
A.	A.	—	—	—	A	A.	A.	—	—	A.	A.	—	—	—	A.	—

A. = Acid Production. — = No change.
The production of Indol was also tested, but negative results were obtained with all the cultures.

The cultures tested were from the following sources :—

Cases.—Nos. 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25 (two cultures—bubo and carbuncle), 26, 27, 28, 29 (two cultures—blood and pustule), 30, 31 (two cultures—blood and pustule), 33.

Animals.—Nos. 1, 15, 74, 84, 96, 101, 112, 117.

Anti-plague Serum.

The anti-plague serum used in the treatment of cases of plague at the Coast Hospital was prepared by Dr. Burton Bradley in conjunction with Dr. Norrie and Messrs. J. Stewart and R. Stewart, at the Biological Institute, Randwick, Sydney. The serum was obtained from two horses, which were immunised by a series of inoculations first subcutaneous and later intravenous, extending over a period of eight months. The serum was, however, first used at the end of a little over two months, in an emergency, when it was recognised that the animals were not fully immunised.

For the inoculations cultures were used of the strain isolated from the plague rat (No. 1) obtained from the s.s. "Wyreema." Subsequently two other strains, one being from a human case (No. 5) were used in addition to the original culture.

The vaccine injected was employed in a strength of approximately 8,000 millions per c.c. Later a more concentrated vaccine was used for the subcutaneous injections. The intravenous injections were first of killed bacteria standardised to approximately 8,000 millions per c.c., and later of living bacilli in approximately the same strength. The details of the inoculations were supplied to us by Dr. Bradley and his co-workers, and are set forth *in extenso* in the accompanying table.

The horses were subsequently purchased by the Department.

Table V.—Preparation of Anti-Plague Serum.

Date of Injection.	Quantity of Vaccine Injected.	Method of Injection.	Bleeding.
	Chestnut Horse.		
28-9-21	7 c.c. (Ord. vaccine stand, 8,000 per c.c.)	Subcutaneous	
6-10-21	13 c.c.	,,	
13-10-21	10 c.c. (Conc. vaccine). (= 60 c.c. ord. vaccine)	,,	
20-10-21	15 c.c. (Conc. vaccine) (= 100 c.c. ord. vaccine)	,,	
31-10-21	5 c.c. (Ord. vaccine). (Dil. to 200 c.c.)	Intravenously.	
7-11-21	50 c.c. (Vaccine and saline)	,,	
10-11-21	50 c.c. (Vaccine and saline)	,,	
18-11-21	100 c.c. (Vaccine and saline)	,,	
23-11-21	200 c.c. (Vaccine and saline)	,,	
5-12-21	.....	.....	5 litres.
7-12-21	10 c.c. (Living and saline).(Stand., 8,000 per c.c.)	Intravenously.	
17-12-21	20 c.c. (Living and saline)	,,	
28-12-21	50 c.c. (Living and saline)	,,	
12-1-22	100 c.c. (Living and saline)	,,	
25-1-22	.....	.....	200 c.c.
2-2-22	.....	.....	Sample—1½ litres.

Date of Injection.	Quantity of Vaccine Injected.	Method of Injection.	Bleeding.
11- 2-22	.....	.....	Sample.
19- 2-22	.....	.....	3½ litres.
22- 2-22	100 c.c. (Living and saline)	Intravenously.	
23- 3-22	50 c.c. (Living and saline—3 strains)	,,	
11- 4-22	.....	.....	3½ litres.
11- 5-22	80 c.c. (Living and saline—3 strains)	Intravenously.	
	Brown Horse.		
28- 9-21	7 c.c. (Ord. vacc.). (Stand., 8,000 per c.c.)	Subcutaneous.	
6-10-21	14 c.c.	,,	
13-10-21	10 c.c. (Conc. vacc.). (= 60 c.c. ord. vacc.)	,,	
20-10-21	15 c.c. (Conc. vacc.). (= 100 c.c. ord. vacc.).....	,,	
31-10-21	5 c.c. (Ord. vacc.). (Dil. to 200 c.c.).....	Intravenously.	
5-11-21	100 c.c. (Ord. vaccine and saline)	,,	
18-11-21	5 c.c. (Living and saline)	,,	
23-11-21	20 c.c. (Living and saline)	,,	
28-11-21	.....	.....	(Not well enough for bleeding—Sample.)
1-12-21	20 c.c. (Living and Saline)	,,	
8-12-21	.....	.....	3 litres.
10-12-21	50 c.c. 8 (Living and saline)	Intravenously.	
22-12-21	100 c.c. (Living and saline)	,,	
19- 1-22	.....	.....	300 c.c.
25- 1-22	100 c.c. (Living and saline)	Intravenously.	
11- 2-22	.....	.....	Sample.
16- 2-22	.....	.....	2 litres.
19- 2-22	.....	.....	3½ litres.
22- 2-22	100 c.c. (Living and saline)	Intravenously.	
16- 3-22	50 c.c. (Living and saline—mixed cultures).....	,,	
23- 3-22	100 c.c. (3 strains)	,,	
11- 4-22	.....	.....	3½ litres.
11- 5-22	100 c.c. (Living and saline—3 strains)	Intravenously.	
20- 6-22	100 c.c. (Living and saline—4 strains)	,,	

Sentinel Guinea-pigs.

Considerable use was made of guinea-pigs as sentinels during the course of the outbreak. These animals were employed in two ways, (*a*) to test the freedom from plague of infected premises during the course, or after completion of the anti-rat measures and fumigation; (*b*) to determine the presence of infection in premises surrounding the infected building. The attached table shows the premises on which the guinea-pigs were placed, with details as to the results, the number of fleas found, &c.

In premises where immediate fumigation by hydrocyanic gas was possible, the use of guinea-pigs as sentinels was not required, but these animals, or rats, were on such occasions used as a test of the efficiency and power of penetration of the poison. Small cage birds (finches) were later used to ascertain that a building was free from the gas on reopening. In premises, however, that were not suitable by construction for H.C.N, fumigation, or in which much material had to be moved, sentinel guinea-pigs were used.

It is not necessary to traverse the whole number of cases in which these animals were employed; reference to the attached table will give the details in individual cases; two special instances may, however, be referred to in more detail.

52 *Day-street.*—Three series of guinea-pigs were placed in these premises during the operations of the anti-rat measures that were being carried out in the building. The first series consisted of two guinea-pigs, placed in the premises on 19th December, 1921, one on the top floor and one on the ground floor. The animals were returned on 23rd December, 1921. The guinea-pig from the ground floor died on the 24th December, 1921, death being due to plague. The guinea-pig from the top floor remained healthy.

The second series was placed in the building on 28th December, 1921, and returned to the laboratory on 31st December, 1921. The guinea-pig from the ground floor was obviously sick on its return, and died from plague on 3rd January, 1922. The other guinea-pig remained healthy. It should be noted that during the interval from 16th December, 1922, to 3rd January, 1922, fourteen infected rats were found in the building.

The third series were placed on 3rd January, 1922, and returned on 6th January, 1922. One guinea-pig died on 9th January, 1921, but from some infection which was not plague.

102 *Sussex-street.*—Two guinea-pigs were placed on the premises on 1st December, 1921, and returned to laboratory on 3rd December, 1921. Seven fleas were found on the guinea-pig from the upper floor. It was discharged from observation on 19th December, 1921, but was found dead in its cage on 22nd December, 1921, death being due to plague. Despite the long interval between its removal from the infected premises and the date of death, there are no grounds for supposing that this animal was infected elsewhere. The second guinea-pig, which was placed in the basement, remained healthy.

A second series of two guinea-pigs was exposed on 28th December, 1921, and returned to laboratory on 30th December, 1921. Both remained healthy till discharged, but one died subsequently (8th January, 1922), no evidence of plague being found *post mortem*.

A third series was represented by a single guinea-pig exposed on 3rd January, 1922, and returned on 6th January, 1922. This animal remained well. One infected rat was found on these premises on 5th December, 1921.

Fleas from Sentinel Guinea-pigs.—In addition to keeping the sentinel guinea-pigs under observation a search of these animals was made on their return to the laboratory, and any fleas found were picked off and examined. The following species were represented :—*Xenopsylla cheopis*, 49; *Ceratophyllus fasciatus*, 2; *Ctenopsylla Musculi* 2; *Ctenocephalus felis*, 4; *Pulex irritans*, 1. These fleas were from five animals only. Plague bacilli were demonstrated in one specimen of *X. cheopis*, from a guinea-pig which subsequently developed plague; the second guinea-pig which developed plague also yielded specimens of this flea.

TABLE VI.—Particulars of Sentinel Guinea-pigs.

Location of Infected Premises.	Associated Human Plague Case or Plague Rat.	Date Human Case Reported or Infected Rats Found.	Number of Guinea-pigs Used.	Cages placed on Premises.	Cages removed from Premises.	Number of days on Premises.	Guinea-pig results.	Species of Fleas found on Guinea-pigs after Removal.						Result of dissection of fleas.
								Xenopsylla cheopis.	*Ctenopsylla musculi.*	*Ceratophyllus fasciatus.*	*Ctenocephalus canis or felis.*	*Pulex irritans.*	Total.	
353 Sussex-st.	Case 1	1-12-21	4	1/2-12-21	5-12-21	3-4	Discharged from observation on 24-12-21.	...	...	...	1	...	1	Neg.
102 Sussex-st.	Case 2	3-12-21	2	5-12-21	12-12-21	7	1 died on 22-12-21. *B. pestis* present.	2	2	2	1	...	7	Neg.
,, ...	,, ...	3-12-21	2	28-12-21	30-12-21	2	1 died on 8-1-22. P.M. No evidence of plague.	...	...	...	...	...	...	
,, ...	,, ...	3-12-21	1	3-1-22	6-1-22	3	Discharged 28-1-22	1	...	...	2	...	3	Neg.
93 Sussex-st.	Rats, 46 and 48.	7-12-21 13-12-21	2	13-12-21	19-12-21	6	Discharged from observation on 24-12-21.	...	...	...	...	...	...	
52 Day-st.	Rats, 49-52 and 54-63.	16-12-21 to 3-1-22	2	19-12-21	23-12-21	4	1 died 24-12-21. P.M. *B. pestis* present.	2	...	...	...	...	2	1 showed *B. pestis.*
,, ...	,, ...	16-12-21 to 3-1-22	2	28-12-21	30-12-21	2	1 died 3-1-22. *B. pestis* present.	...	...	...	...	...	...	
,, ...	,, ...	16-12-21 to 3-1-22	2	3-1-22	6-1-22	3	1 died 9-1-22. P.M. No evidence of plague.	...	...	...	...	...	...	
263-277 Kent-st. ...	Rats, 65-67	19-23-1-22	2	18-1-22	21-1-22	3	Discharged from observation on 11-2-22.	...	...	...	...	...	...	
,, ...	,, ...	19/23-1-22	2	25-1-22	2-2-22	3	1 died 20-2-22: 1 died 21-2-22. No evidence of plague. (Gærtner's bacillus found.)	...	...	...	...	...	...	
118-120 Sussex-st. ..	Rat, 64 ...	18-1-22	2	23-1-22	27-1-22	4	Discharged from observation on 11-2-22.	44	...	...	...	1	45	Neg.
97A Liverpool-st. ...	Rats, 68-73.	6-2-22 to 8-2-22	1	1-2-22	7-2-22	6	Discharged from observation on 4-3-22.	...	...	...	...	...	...	
,, ...	,, ...	6-2-22 to 8-2-22	2	6-2-22	7-2-22	1	1 Discharged from observation on 4-3-22; 1 died on 26-2-22. (Gærtner infection.)	...	...	...	...	...	...	
76 Oxford-st., Paddington.	Case 5	11-2-22	1	22-2-22	28-2-22	6	Discharged from observation on 22-3-22.	...	...	...	...	...	...	
88 Oxford-st.	Rats, 75, 77-79.	22/24-2-22	1	22-2-22	28-2-22	6	Discharged from observation on 22-3-22.	...	...	...	...	...	...	
,, ...	,, ...	22/24-2-22	1	14-3-22	15-3-22	1	Discharged from observation on 8-4-22.	...	...	...	...	...	...	
84 Oxford-st	Case 7	11-3-22	1	8-3-22	15-3-22	7	Discharged from observation on 1-4-22.	...	...	...	...	...	...	
,, ...	Rats, 92 and 84, cat 85.	28-2-22 and 5-3-22	2	13-3-22	17-3-22	4	Discharged from observation on 8-4-22.	...	...	...	...	...	...	
119 Dowling-st., Woolloomooloo.	Cases 9, 13, and 14.	31-3-22	2	28-3-22	4-4-22	7	Discharged from observation on 29-4-22.	...	...	...	...	...	...	
115 Dowling-st.	Case 10 ...	27-3-22	1	28-3-22	4-4-22	7	Discharged from observation on 29-4-22.	...	...	...	...	...	...	
Collins-st., Alexandria.	Case 11 ...	30-3-22	2	1-4-22	4-4-22	3	1 died on 11-4-23. No evidence of plague. 1 discharged from observation on 29-4-22.	...	...	...	...	...	...	
2 Judge-st., Woolloomooloo.	Cases 12 and 15.	30-3-22 and 1-4-22	1	28-3-22	4-4-22	7	Discharged from observation on 29-4-22.	...	...	...	...	...	...	

RAT POISONS.

A number of experiments were carried out on various rat poisons, from the point of view of their lethal effects when fed to rats. No endeavour was made to test the suitability or otherwise of the different poisons from the point of view of taste or other appearance, but it was obvious from the experiments that the baits were not always readily eaten by the rats, and in some cases while the bait was eaten the poison spread on it was avoided. The two principal poisons experimented with were barium carbonate and squills; but a number of proprietary poisons mainly containing phosphorus were also tested.

The tests with barium carbonate were unsatisfactory, in that it was difficult to make the rat eat the baits, even when other food was withheld. Londovus, which contains a large proportion of barium carbonate, was more efficacious. The action of red squills was found to be variable, probably depending on the age of the preparation. Some samples were quite inert, but one bottle proved to be efficient, and graduated doses showed that 2½ c.c. was lethal though 1 c.c. was not.

The various proprietary lines tested for the most part proved lethal to rats. Details of the experiments are given with a summary of the results.

TABLE

TABLE VII.—Summary of Rat Poison Experiments.

Poison.	No. of Experiments.	No. of Rats used.	Rats killed.	Other Animals.	Results.	Remarks.
Londovus	4	3	3	*M. rhesus*	Sick, recovered.	
				Fowl	No effect.	
Barium Carbonate	4	6	0	.....	.....	Baits mostly not eaten.
Red Squills (powdered)	4	5	0	.....	.....	Rats sick when baits eaten, but baits usually untouched.
Ratinin—						
First series	2	1	0	Fowl	No effect.	
Second series	3	3	3	.....	.....	
Third series	4	4	3	.....	.....	Graduated doses, 1 cc. non-lethal, 2½ cc. lethal.
Danzo Rat Killer	4	6	1	.....	.....	One rat died, probably from cause other than the pison.
Noxem Kwick	1	2	2	.....	.....	
Reck and Ringeisens Destroying Paste	1	1	1	.....	.....	
Phosphorus Paste	1	5	5	.....	.....	
Death to Rats	1	6	6	.....	.....	
Ratox	1	1	0	.....	.....	
Ausoline	4	4	2	.....	.....	Bait uneaten in one experiment.
Lime Sulphate	1	1	1	.....	.....	
Stick Fos	1	1	1	.....	.....	

Londovus.—This preparation is stated to contain barium carbonate and squills.

(*a*) Poison spread on squares of buttered bread.
22nd February, 1921—one square fed to R. rattus.
23rd February, 1921—partly eaten, rat sick and died during day.

This rat was kept till the 28th February; on that date a slight smell was noticeable in the morning, becoming more pronounced in the afternoon; the rat was then burnt.

(*b*) 9th March, 1921—two squares spread as above were fed to two R. rattus.
10th March, 1921—small portion of bait eaten; rats sick.
11th March, 1921—rats died at noon.

Carcases kept till 15th March, when strong smell developed, and they were burnt.

(*c*) 9th March 1921—three squares fed to monkey (M. rhesus); baits eaten at once.
10th March, 1921—slight diarrhœa. Two more baits fed to animal and eaten.
11th March, 1921—animal sick.
14th March, 1921—better, and remained well.

(*d*) 6th April, 1921—poison mixed with chopped lucerne and fed to fowl.
Mostly eaten.
No ill effects followed.

Barium Carbonate.—Barium carbonate (7·5 grm.) mixed with oatmeal and dripping plus salt, made into baits. Each bait contained ·5 gramme barium carbonate, 1 gramme oatmeal, ·5 gramme dripping, plus salt.

(*a*) 1st November, 1921—three baits placed in cage with three *R. rattus*.
2nd November, 1921—some of baits eaten.
3rd November, 1921—All animals well.
4th November, 1921—ditto.
5th November, 1921—ditto.

(*b*) 1st November, 1921—one bait in cage with one *R. rattus*.
2nd November, 1921—bait partly eaten.
3rd November, 1921—most of bait untouched.
4th November, 1921—well.
5th November, 1921—well.

(*c*) 1st November, 1921—one bait in cage with one *R. norvegicus*.
2nd November, 1921—bait untouched.
5th November, 1921—bait untouched.

(*d*) 1st November, 1921—one bait in cage with one *R. norvegicus*.
2nd November, 1921—bait untouched.
5th November, 1921—bait untouched.

Powdered Red Squills.—Powdered red squills (10 grammes) was mixed with oatmeal and dripping plus salt, and made into baits. Each bait contained ·6 grammes squills, 1 gramme oatmeal and ·5 grammes dripping, plus salt.

(*a*) 1st November, 1921—two baits placed in cage containing two *R. rattus*.
2nd November, 1921—both baits eaten; rats sick.
3rd November, 1921—better.
5th November, 1921—well.

(*b*) 1st November, 1921—one bait in cage with one *R. rattus*.
2nd November, 1921—bait partly eaten.
3rd November, 1921—portion still uneaten; rat well.
4th November, 1921—well.
5th November, 1921—well.

(*c*) 1st November, 1921—one bait in cage with one *R. rattus*.
2nd November, 1921—bait partly eaten.
3rd November, 1921—portion still uneaten.
4th November, 1921—rat well.
5th November, 1921—well.

(*d*) 1st November, 1921—one bait in cage with one *R. rattus*.
2nd November, 1921—bait partly eaten.
3rd November, 1921—portion still uneaten.
4th November, 1921—well.
5th November, 1921—well.

Ratinin.—A commercial preparation of red squills made in Denmark. The poison is in liquid form, and is to be used poured on to bread slices of ½-in. thickness, 2 oz. being utilised for each slice of bread, which is then cut into squares, yielding approximately 72 squares. It is advised to smear the bread on one side with some attractive paste.

First Series of Experiments.

(*a*) 17th October, 1921—square of bread soaked in Ratinin placed in cage with one *R. rattus*.
18th October, 1921—partially eaten; rat well.
19th October, 1921—well. Fed with extract of squills (Danzo) on bread.
20th October, 1921—bread eaten; well. More bait given.
21st October, 1921—bread eaten; well. Fed with Danzo bait.
22nd October, 1921—well. Fresh bait given and eaten.
24th October, 1921—well.

(*b*) 17th October, 1921—two squares soaked in Ratinin fed to fowl. Eaten at once.
18th October, 1921—well.
19th October, 1921—well. Given bread soaked in extract of squills (Danzo); eaten at once.
20th October, 1921—fed with bread soaked in red squills.
21st October, 1921—well.
22nd October, 1921—well.

Second Series.—A fresh 35 oz. bottle of Ratinin was forwarded for testing by the local agents.

(*a*) 16th January, 1922—bread soaked in Ratinin, placed in cage with a recently caught *R. norvegicus*.
17th January, 1922—bait eaten; animal in pain, rolling about cage.
18th January, 1922—same condition. Animal chloroformed.

(*b*) 17th January, 1922—bread soaked in Ratinin placed in cage with *R. norvegicus* used on the test on Ausoline.
18th January, 1922—bait eaten; animal dead.

(*c*) 18th January, 1922—one inch cube of bread soaked in 13 c.c. of Ratinin placed in cage with one *R. norvegicus*.
19th January, 1922—rat rolling about cage and dying. Died at 3 p.m.

Third Series.—

(*a*) 11th March, 1921—1 in. square bread soaked in 1 c.c. Ratinin and fed to rat.
12th March, 1922—bait eaten; rat well.

(*b*) 11th March, 1922—1 in. square bread soaked in 5 c.c. Ratinin and fed to rat.
12th March, 1922—bait eaten; rat dead.

(*c*) 13th March, 1922—1-in. square bread soaked in 10 c.c. Ratinin and fed to rat.
14th March, 1922—bait partially eaten; rat died after a struggle.

(*d*) 14th March, 1923—1-in. square bread soaked in 2½ c.c. Ratinin and placed in cage of rat previously tested with 1 c.c.
15th March, 1922—rat dead.

Danzo Rat Killer.—This preparation is stated to contain Haller's extract of squills and a suitable broth in proper proportion ready for use after being mixed with grain (flaked oats) or stale bread cut into small pieces.

The preparation was supplied by the local agents of the manufacturers, and the squill powder, which was made in London, was about six months old, but was stated to have been quite satisfactory when used a month previously; ¼ oz. of mixed bait was said to be sufficient to kill a full-grown rat.

The preparation was tried on three rats supplied by the Harbour Trust, all of which had previously been experimented on with other poisons.

(*a*) *R. norvegicus*, previously fed with Londovus by Harbour Trust.
19th November, 1921—bread soaked in extract of squills; bait eaten.
20th November, 1921—rat sick, in pain, throwing itself about cage.
21st November, 1921—dead. *Post mortem* showed hæmorrhage of the pyloric end of stomach, which contained a live full-grown fly maggot; blood-stained fluid in intestine.

Unfortunately, the maggot was not preserved for identification, but was probably *Anastellorrhina augur* Fabr. The same cage had contained the carcase of another rat, and maggots had bred in it and probably this one had been ingested by the rat. The fact that the maggot was alive, and the hæmorrhage and where the maggot was lying, would suggest that the rat had died from an intestinal myiasis. The blowfly found breeding in rat carcases which had been kept after the death of the rat was *Anastallorrhina*, from which it is likely that this maggot belonged to the same species.

(*b*) One *R. norvegicus*, previously fed with Ratinin by Harbour Trust.
19th November, 1921—bread soaked in extract of squill.
20th November, 1921—bread eaten; animal well.
21st November, 1921—fed with red squill; bait eaten.
22nd November, 1921—fed with red squill; bait eaten.
24th November, 1921—rat well.

(*c*) One *R. norvegicus*, previously fed with Londovus by Harbour Trust.
19th November, 1921—bread soaked in extract of squill.
20th November, 1921—bait eaten; animal well.
21st November, 1921—fed with red squill; bait eaten.
22nd November, 1921—fed with red squill; bait eaten.
24th November, 1921—well.

The red squill used in (*b*) and (*c*) on the two feedings subsequent to the initial one wa purchased locally in powder form. It was placed on bread soaked in water. No attempt was made to measure the dose, but a considerable amount was used in each case.

(*d*) 21st October, 1921—two *R. rattus* and one *R. norvegicus* fed with bread soaked in Danzo; baits eaten.
22nd October, 1921,—*R. norvegicus* slightly sick; other two well. Fed with fresh extract.
24th October, 1921—all well.

Miscellaneous Poisons.—These were mainly poisons put on the market by various commercial firms under fanciful names. The contents were not analysed. In each case the directions on the label were followed.

Norem Kwick.—Mixed with water into a dough; on mixing, the original white substance becomes red.
27th November, 1921—Portion placed in cage containing one *R. norvegicus* and one *R. rattus*.
28th November, 1921—*R. rattus* dead. *Post mortem* showed contraction of stomach and intestines. *R. norvegicus* fed again as before.
29th November, 1921—bait not eaten.
1st December, 1921—*R. norvegicus* dead.

Beck and Ringeisens Destroying Paste.—A paste which was spread on bread.
25th November, 1921—portion fed to one *R. norvegicus*.
26th November, 1921—about half the bait eaten; rat dead. *Post mortem* showed intestines intensely congested, and an odour of phosphorous in the stomach.

Phosphorus Paste.—Spread on bread.
27th November, 1921—portion fed to five *R. rattus*.
28th November, 1921—Baits eaten—no apparent effect. More bait placed in cage.
29th November, 1921—all rats dead. Post mortem showed inflammation and contraction of the intestines.

Death to Rats. (Australian Drug Co.)—Mixed with fat.
27th November, 1921—fed to six *R. rattus*.
28th November, 1921—two rats dead; more poison placed in cage.
29th November, 1921—three rats dead.
30th November, 1921—one rat dead.
Post mortem in all cases showed contraction of the intestines.

Ratox (Elliott Bros.)—Mixed with oatmeal and fat.
27th November, 1921—fed to one *R. rattus*.
28th November, 1921—no ill effects; feed repeated.
29th November, 1921—bait not eaten.
1st December, 1921—bait not eaten; ordinary food given.

Ausoline.—
(*a*) 29th December, 1921—spread on bread; portion fed to one *R. norvegicus*.
30th December, 1921—bait not touched; fresh bait placed in cage.
31st December, 1921—the animal would not touch the poison; it ate the bread in between the spread surfaces.
(*b*) 27th March, 1922—spread on bread and cut into 1½-in. squares and fed to rat.
28th March, 1922—portion eaten; rat died.
(*c*) 28th March, 1922—5 grammes ausoline spread on 5 grammes bread; some eaten, no result.
(*d*) Repeated using 8 grammes on 5 grammes bread. Almost all eaten; rat died.

Zinc Sulphate.—
1st October, 1921—a concentrated zinc sulphate solution was placed in cage, no other fluid being supplied.
2nd October, 1921—portion of fluid drunk. Rat obviously in pain, apparently trying to vomit; marked abdominal contractions.
Rat killed; *Post mortem* showed marked contraction of the stomach.

Stick-Fos.—
22nd March, 1922—spread on 1-in. square of bread and placed in cage. Rat died.

[1 map, 1 graph.]

Sydney: Alfred James Kent, Government Printer—1924.