Report of the Board of Health on a second outbreak of plague at Sydney, 1902 / by J. Ashburton Thompson.

1903.

LEGISLATIVE ASSEMBLY.

NEW SOUTH WALES.

REPORT

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ON A

SECOND OUTBREAK OF PLAGUE AT SYDNEY, 1902.

BY

J. ASHBURTON THOMPSON, M.D., D.P.H., President,

Chief Medical Officer of the Government.

Printed under No. 12 *Report from Printing Committee,* 1 *October,* 1903.

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Preface.

July 31*st*, 1903.

On reviewing the events of the epidemic of 1902, it appears that they justify and enforce the advice on management of epidemic plague which was given in the official "Report on the Outbreak of Plague at Sydney, 1900"; this, therefore, need not be repeated on the present occasion, which will be used to investigate further the causes of epidemic plague.

2. In other parts of the world, the maintenance and spread of plague are ascribed to human intercourse—directly with the sick, or indirectly through articles which have been infected by them—and to place-infection.

3. It has been shown that the epidemic of 1900 was not caused by direct communication with the sick, nor by diffusion of infected articles, nor by place-infection. These observations on the mode of spread we have now had opportunity of checking. They have been confirmed and amplified.

4. The share which may be played by the rat in causation of epidemic plague has been left a doubtful matter by the evidence which has been gathered elsewhere. All that has been ascertained is that man and the rat are susceptible of an identical infection. That plague is primarily a disease of the rat; that it is commonly communicated to man from the rat; or that man and the rat in usual circumstances of propinquity are reciprocally infective, have but been shown to be probable conjectures; for it has also been said* that sometimes an epidemic has taken precedence of the epizoötic, and even that in different places each has run its course unattended by the other. In short, no more than an occasional, though frequent, concurrence between the two has been remarked, and the question whether epizoötic plague be a cause or an incident of epidemic plague has been left unanswered by the observations thus far recorded in other countries.

5.

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* Indian Plague Commission, Report 1901, Section 292.

5. Here, in Sydney, we formed the opinion in 1900 that plague-rats constituted the sole source from which the infection was communicated to man. A good deal of evidence in support was furnished, but it was, and under then circumstances almost necessarily was, incomplete. It has now been largely supplemented. How far it reaches towards demonstration of causative association between plague-rats and individual cases of plague is left to the reader's judgment. It is shown below that the task of fully examining into, and of exhibiting, the relationship referred to is one of great difficulty in any city.

6. But supposing the invariable precedence of rat plague and a constant association of plague-rats with individual plague cases to be established: Another and important difficulty presents itself, which is that in all probability the rat unaided cannot cause epidemic bubonic plague. An intermediary is necessary to convey this septicæmia of the rat to man. Whether that intermediary may consist in inanimate objects on which plague-rats have deposited the infection in a way to facilitate its effective contact with man, is a question which is discussed at length below. Some ground for answering it in the negative is there shown.

7. It has been already noted (Report, 1900, p. 38) that Simond had suggested in 1898* that the requisite intermediary might be furnished by the flea and the bed-bug. Personally, I had accepted this suggestion before the disease had appeared here, on the ground that it served to explain a greater number of reported, and apparently discordant, observations than any other which had been made; and when the first case of the epidemic of 1900 occurred which, as it happened, indirectly exemplified it, I took it for guide, although the proofs adduced had remained uncorroborated, and although direct experiments by Nuttall† (which were made, however, with Cimex only) had yielded negative results. By the end of that epidemic it had been generally accepted in this Department on the ground that it, and it alone, appeared capable of co-ordinating the observed facts; and, notwithstanding an adverse remark on "rat-fleas" made by Netter‡, and vivacious contributions on the same subject by Professor Galli-Valerio§, which intervened, we regarded it with similar favour at the end of the second epidemic. Attention has now been given to determining the species of the fleas which infest rats in this part of the world, to variations in their frequency on rats at different times, and to examining into their ability to bite man.

8. The importance of the foregoing remarks, which, to those who are content with the simple theory which is expressed in the one word "rat," will appear recondite and superfluous, lies in this: That while our experience regarding non-diffusion of the infection by direct or indirect communication with the sick and non-maintenance by place-infection, is not the same as has elsewhere been recorded, it has yet been acted upon by us with an apparent diminution of the number of persons attacked, together with large saving of direct expenditure, and avoidance of many of the indirect occasions of loss to individuals which, in spite of our advice, were caused to operate so largely during the first epidemic.

9. And now, unnecessary though it be to repeat all the advice on management of epidemic plague which was given in 1900, because it has but been corroborated by the further experience of 1902, it is yet well to recall the most important of the lessons which we then inculcated. This, repeated to-day with the emphasis which such corroboration warrants, runs as follows:—The promise of safety for the future lies neither with attempts to prevent the importation of plague-rats (which must fail from time to time), nor with attempts to exterminate the rats infesting the locality to be defended (which we have learned is practically impossible), though both of these measures have their valuable uses, but in habitually excluding rats from inhabited premises. This, manifestly, is a defence which can be set up successfully by Local Authorities; it requires persistent effort, but involves hardly any expenditure of municipal funds.

* Annales de l'Institut Pasteur, 1898. † Johns Hopkins Hospital Reports, VIII, pp. 17-21. ‡ La Peste et son Microb., Paris, 1900. § Cent. f. Bakter, XXVII, p. 1, and XXVIII, p. 842.

Part I.—The Epidemic.

10. The last case of the epidemic of 1900 was notified on 9th August of that year. An interval of rather more than fifteen months ensued, during which careful watch was kept for commencement of the recurrence which was feared; but among the many cases which were reported for diagnosis during its continuance, there were but two which afforded good ground for *primâ facie* suspicion, and after investigation it was shown that both were due to streptococcic infection. The rats which infested the areas on which cases had arisen were also watched until it appeared probable that the epizoötic of plague which had prevailed among them had died out.

11. That long interval was determined by attack of a man on 4th November, 1901; his case was notified on 12th November. A free term of thirty-four days ensued, and then, on 8th December, a second man was attacked. After a further free term of about thirty-five days, a woman fell ill on 10th or 11th January, 1902. During these two intermissions several cases of illness were reported for diagnosis, but no case of plague, nor any in which there was real ground for doubt, was among them. The epidemic declared itself with the third case, and, as the last patient was attacked on 8th June, it may be referred to conveniently as the epidemic of 1902. It consisted of 139 cases, of which 39 ended fatally, and is the subject of the present account.

12. On 6th August, however, one further case occurred at Newcastle. It was "indigenous" to that city, but, thanks to the measures immediately taken it remained solitary, and the danger to which that important seaport had been exposed was averted. It is separately described below.

Management of the Epidemic.

13. Management of the epidemic rested with the Board of Health. Mr. Edmund Fosbery, C.M.G., who had been appointed by the Board to act as President during my absence on leave, and the Principal Assistant Medical Officer of the Government and Micro-Biologist to the Board (Dr. Frank Tidswell, M.B., D.P.H.), who at the same time had taken up the duties of the chief executive post, occupied those positions at its beginning. I resumed control on 7th March.

14. The method of management differed essentially from that actually followed in 1900 in three important respects. First, in 1900 we had pointed out, in the course of our report on the case of A.P. (Case 1), dated 7th February, that the Coast Hospital was the only suitable place to which plague cases could be sent for isolation and treatment, and had repeated this recommendation several times during the earlier part of the epidemic. Secondly, we had announced, on 2nd March (Case 5), that it was unnecessary to segregate contacts, and that for the future we should, as a rule, remove only the sick from dwellings. Thirdly, on 23rd March (Case 32), we had so far expressed our opinion as regards probable diffusion of infection by merchandise as to give instructions that the latter might be removed in the ordinary course of trade from the Adelaide Bond, which stood on that infected area which was the first to be quarantined for cleansing. But the head of the Government of the day declined these several advices; and, as a matter of fact, patients were strictly isolated in the buildings, utterly inadequate to this purpose, and accessible with difficulty, which alone the Maritime Quarantine Station at North Head afforded, all contacts were segregated at the same place, and cleansing areas were as strictly closed, or "quarantined," during cleansing as physical circumstances permitted.

15. In 1902 our advice was implicitly accepted; and consequently, as regards the three points mentioned, we did as we had wished to do in 1900. First, the sick were sent to wards within the Infectious Diseases Division of the Coast Hospital, where they were dealt with almost exactly as though they had been suffering from measles or from some other of the commoner infectious fevers; the only difference was that visitors, though discouraged, were more freely admitted than would have been the case had the disease been measles in fact. No other special precaution was taken than that of rendering the wards rat-proof; and the general economy of the hospital was disturbed only by the number of patients suffering from this one disease for whom

whom accommodation had to be found. Secondly, the sick alone were removed from their dwellings. The other members of the households to which they belonged were not interfered with. They were told that their premises were probably infective, and were advised to withdraw from them until they had been disinfected, when the circumstances required this, but they were never compelled to move; neither were they supervised, except for a short time quite at beginning of the epidemic. Pending completion of disinfection, entrance to the house where the patient had lain was forbidden to all but the residents, but the latter were allowed to go in and out. Disinfection was always very promptly done, and was usually finished within thirty-six hours of the patient's removal; though in the case of extensive premises the time was much lengthened, and access to theatres, hotels, and the like was denied to the public until the structural repairs necessary to exclude rats had been completed. Thirdly, areas which were deemed to be infective were rapidly and thoroughly cleansed, but they were not closed during that operation; movement of population and trade were in no way interfered with.

16. These changes constituted remarkable ameliorations. Were they beneficial under all aspects? The following comparison permits the inference that they were so, and in a striking degree.

Table I.—Comparing the Epidemics of 1900 and of 1902, as regards number of attacks, fatality, and cost.

Epidemic.	Number of		Fatality.		Cost.
	Cases.	Deaths.	Gross.	Chinese Excluded.	
					£
1900	303	103	34·0	32·4	176,000
1902	139	39	28·0	25·75	24,000

Progress of the Epidemic.

17. At the Census of 1901 the population of the Metropolitan Registration District was 487,932, and this included a total of 3,842 Chinese, of whom only 222 were females. Among the whites 132 cases of plague occurred, of which 34 ended fatally; among the male Chinese 7 cases, of which 5 ended fatally. The manner in which these cases made appearance is shown in the Table below.

Table II.—Showing the number of attacks which occurred in each week of the epidemic, and the number of weekly attacks which ended fatally; together with the number of cases notified during each week.

	Attacks.	Deaths.	Notifications.		Attacks.	Deaths.	Notifications.
1901.				1902—(*contd.*)			
9 November	1	0	0	8th week— 1 March	14	4	16
16 „	0	0	1	9th „ — 8 „	5	0	7
30 „	0	0	0	10th „ —15 „	12	5	10
23 „	0	0	0	11th „ —22 „	18	3	14
7 December	0	0	0	12th „ —29 „	8	1	12
14 „	1	1	1	13th „ — 5 April	5	0	5
21 „	0	0	0	14th „ —12 „	1	0	4
28 „	0	0	0	15th „ —19 „	6	1	4
1902.				16th „ —26 „	8	2	7
4 January	0	0	0	17th „ — 3 May	5	3	7
1st week—11 „	1	0	0	18th „ —10 „	6	1	8
2nd „ —18 „	2	0	1	19th „ —17 „	7	3	5
3rd „ —25 „	3	1	5	20th „ —24 „	2	1	3
4th „ — 1 February	0	0	0	21st „ —31 „	2	0	1
5th „ — 8 „	5	2	5	22nd „ — 7 June	5	2	3
6th „ —15 „	9	4	7	23rd „ —14 „	1	0	5
7th „ —22 „	12	5	8		139	39	139

18. The first case occurred during the week ending 9th November, 1901. For thirty-four days it stood alone; a second then happened during the week ending 14th December. After another interval of thirty-five days a third person was attacked during the week ending 11th January, 1902, and with this the epidemic began. The first two cases being excepted, during the first six weeks (ending 15th February) 20 persons were attacked; during the second six weeks, 69 persons; during the third, 31; while during the latter five weeks, only 17 were attacked. These figures, which result from division of the series shown in Table II, column of attacks, in accordance with the marked increase in the weekly number of attacks during the seventh to the twelfth weeks, distinguish periods of increase, state, and decline of the epidemic. The onset of the epidemic was marked by extreme deliberateness at first, and by an almost regular acceleration in its later stages; while its end during the week ending 14th June was abrupt and decisive. No doubtful cases were met with thereafter.

19. *By whom notified.*—Of the above cases, 22 were notified from public hospitals, 92 by fifty-five medical practitioners, and the remaining 25 by staff medical officers, by coroners, by the police, by friends, and by themselves, in about equal numbers.

20. *Cases reported for Diagnosis.*—Between 12th November, 1901, when the first case was notified, and 31st July, 1903, 112 cases of illness, which turned out not to be plague, were reported for diagnosis. Only one of them afforded good clinical ground for doubt, but the morphological, cultural, and inoculation tests which were applied to liquid abstracted from a swollen inguinal gland failed to reveal any micro-organism or any infective disease. One other gave clinical ground for doubt in a lesser degree, and was shown to be a case of streptococcic infection connected with a chronic ulcer of the leg.

21. *Ambulant Cases.*—These did not exceed seven or eight in number altogether. But they could not be exactly discriminated, because they were exhibited both in persons who had personally applied for treatment immediately after attack and who subsequently passed through a well-marked illness, and in persons who had passed through a mild acute stage without medical aid, and who applied for help during convalescence, either for persistent weakness or for indurated and painful glands. This, with addition of two or three cases which ultimately came to light in consequence of late suppuration of glands, is what was observed during the epidemic of 1900; and, as on that occasion, the circumstances under which these cases came to notice render it likely enough that a few others may have occurred in which either advice never appeared to be necessary, or else was sought at so late a date that the true cause of illness was not discovered. Neither in 1900 nor during the epidemic under notice did we note anything which would give colour to a suggestion that cases of pestis minor occurred, or cases of benign glandular enlargement probably taking their origin from a very mild and successfully resisted infection with plague. We have no practical knowledge of either of these described conditions.

22. *Clinical Forms.*—Of the 139 cases, 133 were of the bubonic form, 6 were of the septicæmic form. These proportions were practically the same as were observed in 1900, and, as on that occasion, no case of primary plague-pneumonia was met with. The general course of the disease was the same as has been already described (see Report, 1900, pp. 3–7), but the following three clinical notes are worthy of record.

23. *Mode of Onset.*—This was often sudden. Thus the exact hour of attack was named by 22 patients; that is to say, they alleged that having been in good health they had fallen ill "at 5 o'clock in the morning," or "at half-past three in the afternoon," &c. In 71 cases, though the hour of attack could not be exactly fixed, yet it was ascertained to have been during the first 6 hours after midnight in 9 of them, during the second 6 hours in 18, during the third 6 hours in 22, and during the fourth in 22. So in 19 other cases in which nothing exact was noted on this point, in 8 the attack was said to have been "sudden," and in 11 others to have occurred "while at work." In 14 cases the onset was definitely ascertained to have been gradual.

24. *Onset Symptoms.*—These almost always consisted in headache and general malaise, nausea, followed sooner or later by vomiting, and shivering; a feeling of feverishness set in early, or else after a few hours. To these symptoms diarrhœa and colic were rather often added. At the onset, also, the patient's attention was frequently attracted to the gland in which the bubo afterwards developed. Thus, in 13 cases sharp and continued pain in the gland, accompanied or not by perceived enlargement, preceded all other symptoms, and was the first indication that the infection had been received; while in 24 others, similar pain with or without swelling was noted to have been among the onset symptoms, and to have been noticed as soon as headache, shivering, &c. had informed the patient that he was ill.

25. *Situation of Buboes.*—In 123 instances (32 deaths) the bubo was solitary; in 106 of these it was situated in the inguinal region, having been in one of the vertical set of glands in 60, and in one of the oblique set in 46 of them. In 10 instances (3 deaths) the glandular enlargements were multiple: in 2 instances (1 death) in two regions on the same side; in 7 instances (2 deaths) in the corresponding regions on two sides; and in 1 instance in two corresponding regions on two sides of the body. In 6 instances (4 deaths) there was no bubo.

26. *Interval between Attack and Notification.*—This can be stated in 139 cases, and was as follows:—

TABLE III.—Showing the interval which elapsed between attack and notification in 139 cases of plague.

Notified on the day of attack	10
„ one day after „	31
„ two days after „	27
„ three „ „	31
„ four „ „	13
„ five „ „	9
„ six „ „	5
„ seven „ „	2
„ eight „ „	4
„ nine „ „	2
„ ten „ „	3
„ eleven „ „	1
„ twenty-three days after attack	1
Total	139

27. *Interval between Notification and Removal.*—This has administrative as well as ætiological interest. It was as follows:—

TABLE IV.—Showing the time which elapsed between the notification of cases, and their removal to hospital.

Removed on the day of notification	90
„ one day after „	28
„ two days after „	6
Not removed, having fallen ill in country	1
Died before or at notification	14
Total	139

So that of 124 patients who could be dealt with in the ordinary course, 118 were removed to hospital either on the day of notification, or, having been notified too late for removal by daylight, the next morning; while removal was deferred for two days in the remaining six cases, because the state of the patient at the date of notification was such as precluded his immediate removal with safety.

28. *Protective Inoculation.*—No public, and very little detail, inoculation was done during this epidemic. Two alone of the persons attacked asserted that they had been inoculated. Case 2: The patient was said to have been inoculated (Haffkine) at Rockhampton, Queensland, nearly 2 years before attack; this statement was verified*; he died. Case 95: The patient alleged that he had been inoculated (Haffkine) early in 1900, at Sydney, but his name could not be found in the list of names of persons then publicly inoculated; he recovered.

29. *Sex-incidence.*—Somewhat more than twice as many males were attacked as females. In 1900, this proportion was very much larger.

30.

* By Dr. B. Burnett Ham, Commissioner for Public Health, Queensland.

30. *Age-incidence.*—The observed incidence was on ages 4 years to 75 years. About 60 per cent. of the total cases were aged between 15 and 35, and about 80 per cent. were aged between 15 and 45. A larger proportion of persons both above and below the age-groups mentioned was attacked in 1900.

TABLE V.—Showing the number of attacks and of deaths distributed under Sexes and Age Groups.

Age Group.	5		10		15		20		25		35		45		55		65		75		Total.	
Sex.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
Attacks...	0	1	4	2	13	6	12	3	8	8	25	9	20	9	7	1	2	2	5	2	96	43
Deaths ...	0	1	1	0	3	1	4	0	4	0	6	3	6	2	1	0	1	2	2	2	28	11

31. *Fatality.*—The total number of cases having been 139, and the deaths 39, the gross fatality was almost exactly 28 per cent.; and this was rather more than 6 per cent. below the gross fatality observed in 1900. Some part of this reduction may be apparent, and due merely to the smaller number of cases and of deaths dealt with; but as the gross fatality of 34 per cent. in 1900 was reduced to 32·4 per cent. for whites only, by deduction of 10 cases and 8 deaths among the Chinese, so the gross fatality of 28 in 1902 is reduced to 25·75 for whites only, on subtraction of 7 Chinese, and of the 5 deaths which occurred among them. These deductions are justifiable on the ground that experience has shown that the Chinese (and other coloured races) always resist this disease very much less successfully than do the whites.

32. *Fatality at successive periods.*—The fatality of the disease in each of the four successive periods already mentioned was as follows:—

TABLE VI, showing the fatality of the disease during four successive periods of the epidemic.

Period.	All cases.			Chinese deducted.		
	Cases.	Deaths.	Fatality.	Cases.	Deaths.	Fatality.
Early cases	2	1	...	2	1	...
1st– 6th week	20	7	35·0	20	7	35·
7th–12th „	69	18	26·0	67	17	25·3
13th–18th „	31	7	22·5	28	4	14·3
19th–23rd „	17	6	35·3	15	5	33·3
Totals	139	39	28·0	132	34	25·75

33. If the Chinese be deducted the fatality for these four successive terms becomes 35, 25, 14, and 33. The smallness of the figures dealt with may account for some irregularity in the series; and if the 4 periods be reduced to 2, namely, of 12 and of 11 weeks, then (the Chinese being still excluded) the fatality during them was 27·6 and 21· respectively. This seems to point to a diminishing virulence of the infection. But as the second term yielded but 43 cases much stress cannot be laid on this inference; and if the fourth column of the preceding Table be referred to, it appears that the fatality during the last of the four periods was rather above that of the first period. In this comparison, too, however, the figures are too small to carry weight. And yet just as it was necessary to point out that cases which seemed to betoken unimpaired virulence of the infection were met with at the very end of the epidemic of 1900 (Cases 289, 295, and 303), so now it has to be noted that of 6 persons attacked during the last fortnight of the second epidemic, 2 died, while one of these illnesses (Case 134) had a duration of

seventy-five

seventy-five hours only, although the patient was a man of 24, and in excellent health at the time he received the infection. Extinction of the epidemic was not due, then, to enfeeblement of the virus, or if in some degree due to this, was not due to it alone.

34. *Fluctuation in the weekly number of attacks.*—The larger number of persons attacked during the second period of six weeks, was almost entirely associated with the city of Sydney, and very largely with that central part of the city along which George-street runs, and which is bounded on the west by Darling Harbour. That is the centre of the business portion of Sydney, and consequently is more thickly populated during day-light hours than any other. The persons referred to did not live in this locality, or did so in very small proportion; they merely resorted there during the day. Those of them who resided at a distance did so for the most part in neighbourhoods which there was no tangible reason for suspecting of infection with plague; on the other hand, they were easily connected with individual premises in that part of the city which were either shown to have yielded dead rats in number, or in the immediate neighbourhood of which rats actually infected with plague had been identified. In short, the weekly increase referred to appeared to be associated with wider prevalence of the epizoötic on a thickly-populated area.

Communication between successive Cases.

35. This was the subject of careful inquiry in every case. No communication was detected or suspected between any case and a preceding case, except on premises which yielded multiple cases; except also the 4 cases which occurred at 2 adjoining cottages on the Paddington area; except, also, 3 cases which occurred in two adjoining cottages on the Pyrmont area; except, lastly, case 102, Chippendale area, with which patient at the time of her attack (18th April) was a woman who had been seized 20th February, admitted to hospital 26th February, and discharged therefrom 18th March. All of the instances referred to are fully described in their place, and the nature of their relation to each other is there discussed at length.

Evidence as to Place Infection.

36. The Plague Commission in India summed up the evidence it had gathered as to place-infection and the maintenance of the disease by that condition in the following sentences:—" . . . the universal experience of plague in India proves . . . that houses into which the infection of plague has been imported, whether by men or by rats, are infective . . . "; and "the general experience on this question is summed up in the expression current in India that plague is essentially a disease of locality."* What evidence on this important point has been furnished by experience at Sydney?

37. In 1900 the number of dwellings which *harboured* cases of plague (that is to say, whether they were or were not adjudged places of infection for those cases) was 286. Only 10 of them yielded multiple cases; in 3 of them the secondary cases occurred before removal, and at or near the same time as the primary case; in 4 the secondary cases occurred after separation from the primary case, and from the dwelling; and in 3 only did the secondary cases occur among the household after its removal from the premises, after the latter had been disinfected, and after the household had returned to them. In this small minority of 3 dwellings out of 286, then, there was *primâ facie* evidence of place-infection; and the whole of that inquiry went to show that the epidemic was associated with place in some sense or another. But this localisation of the infection was considered to have consisted merely in the casual presence of plague-rats; and it was pointed out that infectiveness of some of the premises standing on an area otherwise known to be infective was just what might be expected to continue notwithstanding disinfection if it depended on the incoming of infected rats, and not on infection resident in the place itself.†

38. Further, 221 premises (whether dwellings or places of employment) were adjudged in 1900 to have been places at which 255 cases had received their infection (see Diagram C, 1900).

39.

* Report 1901, par. 221. † Report, Sydney, 1900, p. 38.

39. Now, as regards 1902, we have in the first place to ascertain whether the second epidemic recurred on the same areas as were affected in 1900; and in order to judge this broadly, reference should be made to Diagram I.* On this 208 red spots have been placed which represent a corresponding number of adjudged places of infection in 1900; there are also 86 blue spots which represent the adjudged places of infection for 113 cases, in 1902.

40. It will be first noticed that red and blue spots are largely mixed together, and it will also be immediately perceived that on any hypothesis of spread, this must have been so to some extent, the reason being that while both sets of spots represent cases in man, the population among which they occurred was the same on both occasions, occupied the same area, and dwelt or worked in the same buildings; but on closer examination it will be found that large areas which carried many places of infection in 1900 were entirely spared in 1902. Secondly, when the individual premises are examined, it appears that out of the 286 houses which *harboured* (see par. 37) cases of plague in 1900, only eight again harboured cases in 1902. They were the following:—

1. Central Exchange Coffee Palace.—Case 135; cases 52, 53, and perhaps 2 others.
2. 47–51, Sussex-street.—Cases 2 and 29; case 42.
3. Her Majesty's Theatre and Hotel.—Cases 243 and 264; cases 18, 19, 20, 21, 33.
4. Criterion Theatre and Hotel.—Cases 227 and 236; cases 26, 27, 29, 31, 32, 39, 40.
5. Louden's Boot Factory, Elizabeth-street, Redfern.—Case 239; case 139.
6. Pier Hotel, Manly.—Case 257; case 110.
7. Saxton and Binn's Timber Wharf.—Cases 126 and 302; case 78.
8. 86, Windmill-street, Miller's Point.—Case 22; case 130.

41. The first 4 of these places were adjudged places of infection in both epidemics; the next 2 were so regarded in 1900 only, and the latter 2 in 1902 only. In 1900 the epizoötic extended to Manly, and there was a clear history of removal of dead rats by the patient, shortly before his attack, from the basement in which he was chiefly occupied. But in 1902 the most careful inquiry of the patient, who was a barmaid, and who apparently gave a full and straightforward account of her movements during the ten days which preceded her attack, entirely failed to reveal any probable source of her infection; the epizoötic having been ascertained as well as possible not to have extended to this waterside suburb on the latter occasion. As regards the last house mentioned in the above list it yielded in 1900 a single case of fulminant plague in a little girl; the house was old, and presented no signs of unusual infestation with rats. It was doubtful whether the patient had contracted the disease on the premises which, however, stood in the immediate neighbourhood of wharves in a locality largely occupied by warehouses, bonded stores, and the like places, and quite near to the lane in which the first case of that epidemic had occurred some two months earlier. In 1902 another little girl living in this house, but belonging to another family, was attacked; and, again, although the house yielded some evidence of infestation nothing definite nor, indeed, very suspicious, was discovered. But there was this slight difference in the known circumstances in 1902—a plague-rat had been collected on April 9th (the case occurred on May 15th) at Walker's Wharf, which was one of the line above which the house stood on a ridge. There was thus evidence of infection in the neighbourhood in 1902 which was wanting in 1900, though it may, nevertheless, well have been present then. Nothing of importance can be added concerning the 5th and 7th of the premises in the above list.

42. These 4 cases are, in my opinion, insufficient to raise a doubt; and the proper conclusion to be drawn from the whole number is that in those 4 most probably all the circumstances have not become known. The fact is that of

* Diagram I corresponds with diagram C attached to the Report, 1900; but whereas diagram C exhibited 255 spots, diagram I shows only 208. The main reason is that the spots on diagram C represented *cases*, but those on diagram I represent *places*; with the result that the number of spots then shown is reduced by 34. Besides this, diagram I does not cover quite as great an area as diagram C, and consequently 10 spots just to the east of its boundary, and 3 just to the south of it, are not shown; no cases having occurred in 1902 in the neighbourhoods thus indicated, nor beyond them.

of 6 premises which were adjudged places of infection in 1900, 4 were also adjudged places of infection in 1902. But the total adjudged places of infection in 1902 was 86; it follows that 80 of them were infected for the first time in 1902, while, on the other hand, 221 less 6 or 215 houses adjudged to have been places of infection in 1900 were spared in 1902: whence it is plain that the infection of 1900 showed no tendency to persist on individual premises. It will be noticed, also, that the 4 premises on which cases were adjudged to have been infected both in 1900 and in 1902, were used in ways known to be likely to attract rats to them.

43. It may be objected that so far cognisance has been taken only of premises in relation to cases in man, and that all of them were disinfected so effectually that the virus had no opportunity of establishing itself upon them. But the statement is that place-infection can also originate with introduction of infected rats to premises; now, although all those premises on which plague-rats were found were disinfected as carefully as though cases, too, had occurred upon them, yet it cannot be pretended that plague-rats were detected on all the premises which they had visited, or even where they had died. It might be supposed, therefore, that the 80 places of adjudged infection, apparently first made infective in 1902, may really represent that residuum of the many places which had been infected by plague-rats in 1900, which had then escaped disinfection, in which the virus had (*a*) succeeded in persisting, and in which (*b*) circumstances had secured its communication to man in 1902. To this, of course, no direct reply could be made. But after perusing the description of the mode of spread below, the reader will be in a position to judge how far the ascertained cause of the infectiveness of these houses in 1902 discounts the speculative supposition mentioned.

44. I conclude that there is no evidence of the occurrence at Sydney of place-infection in the Indian sense, and that the infectivity of premises in 1902 was due to the presence on them of the plague-rats of 1902.

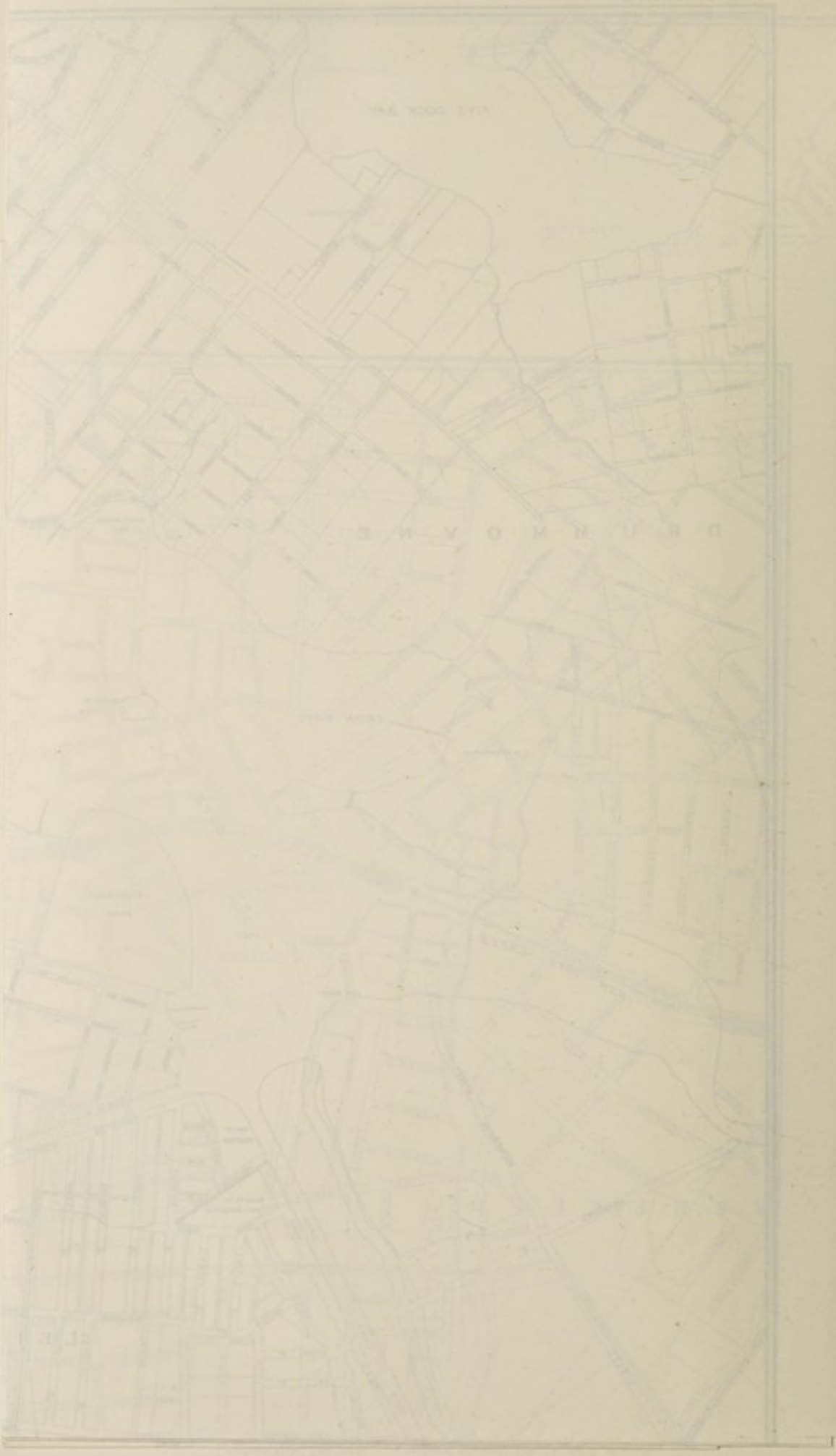
Cases in which the place of Infection remained undetermined.

45. From the total 139 cases, one, attacked on board the ship "Eulomene," may be excepted; it is fully described below. Of the remaining 138 the place of infection was determined in 113; and that number of cases were adjudged to have received the infection on 86 different premises. Remain, therefore, 25 cases in which the available information did not suffice to indicate any particular place as probably having been that at which the infection was taken. Two of the 25 were Chinese; 4 of them were idlers or prostitutes; 3 were labourers out of work, who were taken ill while searching for employment; 3 others were boys under 15; and 3 were either rat-catchers or scavengers in employment of the local authority for the City of Sydney, whose occupation led them into special danger at many different places. There remain 10 cases, therefore, in which it might be reasonably expected that the place of their infection would be discoverable. The history of each of them prior to attack was very carefully inquired into, and although nothing of apparent importance was elicited, the following data concerning some of them are worth mention. One was a druggist; one was a groom, who slept over a stable and in the same building with his horses'-feed; another was a clergyman actively occupied in district-visiting; another habitually gathered mill-wastes for poultry-feed at places on the Darling Harbour area (see page 31); another was an unemployed man, apparently not an idler, but whose movements were obscure. Other 3 were housewives, one was a waitress at a restaurant, and one a barmaid (see par. 41). Evidently many of these persons ran, or were likely to run, into danger in the course of their occupation or idle wanderings, at a time when plague was epizoötic and epidemic.

Origin of the Epidemic.

46. The only hypotheses worth serious examination, in our opinion, are the two following: Either the epidemic depended on a recrudescence of the epizoötic of 1900, or upon a second epizoötic set going by newly imported plague-rats. As to the former, we had reason to believe that the epizoötic of 1900 died out in the course of that year, but the evidence gathered was insufficient to establish the fact; still, the recurrence was apparently too long delayed to have been a recrudescence, the interval


PREPARED FOR THE DEPARTMENT OF PUBLIC HEALTH
MAP OF THE
CITY OF SYDNEY
AND
ADJACENT MUNICIPALITIES.
1903
COMPARING THE POSITION OF 208 ADJUDGED PLACES OF INFECTION IN 1900 WITH THAT OF 86 SUCH PLACES (SEE PARAGRAPH 30 IN 1902), AND DISTINGUISHING 7 WHICH HARBOURED CASES IN BOTH THOSE YEARS.
EXPLANATORY NOTES
NOTE
DRUMMOYNE
LEICHHARDT
ANNANDALE
CITY OF SYDNEY
ASHFIELD
PETERSHAM
CAMPERDOWN
DARLINGTON
MARRICKVILLE
ALEXANDRIA
WATERLOO
WOOLLAHRA
CENTENNIAL PARK



interval of fifteen months which elapsed before the disease again occurred having extended far beyond the time at which generations of new and susceptible rats had come into existence. Further, it will presently be shown that the state of rats as to disease was very carefully, and it is thought completely, ascertained over the whole of the threatened area from conclusion of the epidemic in June 1902, to 31st December, while from the latter date the wharfs were watched in the same thorough way until far into 1903. Now, the last plague-rat was discovered on 13th July, 1902; consequently there is good ground for asserting that the second epizoötic, at all events, died completely out: and therefore, as regards commencement of the second epizoötic, the balance of evidence at Sydney appears to tell in favour of reimportation. But this matter requires further observation in the field, and experiment in the laboratory, as the short table below concerning Western Australia pointedly suggests.

47. As to reimportation, Sydney remained in the communication by sea with all those ports in other parts of the world at which plague existed between August 1900 and November 1901, which was described before, (Report, 1900, p. 21), ports in New Caledonia alone excepted; but to them must be added some danger from two States of the Commonwealth, namely Western Australia and Queensland. The facts as regard Western Australia are shown in the table below:—

TABLE VII.—Showing the dates on which successive outbreaks of Plague in the State of Western Australia began and ended.

Year.	Number of Cases.	Locality.	Duration.
1900	6	Fremantle ...	April 5—June 18.
1901	23	Perth, Fremantle, and Kalgoorlie ...	March 1—May 11.*
1902	3	Fremantle ...	May 19—July 4.
1903	9	Fremantle ...	January 26—May 24.

* The cases occurred at Perth and in its suburbs for the most part; 2 at Fremantle, probably of local origin; and 1 at Kalgoorlie, a very distant place, thought also to have been infected at Perth.

Fremantle, at the mouth of the Swan River (population 16,367) is the port of Perth, which lies 12 miles higher up. Vessels coming foreign berth alongside; they do not ascend the river, but goods are carried up on lighters.

48. The important facts as regards Queensland were as follows in 1901:—

TABLE VIII.—Showing the cases of plague in rats and in man at Brisbane during the latter half of 1901.

	Cases in—	
	Rats.	Man.
July	20	3
August	8	1
September	1	.....
October	.....	1
November	1	.....
December	.....	1

49. One case was also reported from Bundaberg, Q., on 17th April, and one from Cairns, Q., on 16th July, both of which are seaports. Thus prior to November, 1901, the port of Sydney was in danger of importing plague-rats from Queensland, with which it is in daily communication by sea (by rail also with Brisbane), and perhaps also from Fremantle, though this seems uncertain. Precautionary measures were taken against this danger both at the distant ports mentioned and at this port, but these, as has already been pointed out (Report 1900, p. 44), cannot be relied upon invariably to prevent it. And it will be seen below that the rat-staff organised as soon as occurrence of Case 1 became known did on the second day of search (18th November) take a plague-rat at Howard Smith & Co's. Brisbane wharf; this being one of a line of wharfs, on the eastern side of Darling Harbour, at which produce is habitually landed, and the case having occurred at a produce store in the city which was distant from it. Nevertheless we are not at liberty to assume without reserve that the infection was brought hither either from Queensland or from Western Australia; for a vessel which has received plague-rats at a very distant port has arrived at Sydney after

after a voyage at sea which had lasted so long as 29 days with some rats still alive, and actually suffering from plague at the time of her arrival. This occurrence was observed in March 1901, and was as follows:—

The Case of the S.S. "Antillian."

50. The chartered troopship "Antillian," a steam vessel of 3,686 tons, entered Sydney Harbour, March 2nd, 1901, and brought to at the Boarding Station. She had left Capetown, February 1st, and presented a clean bill of health issued to her at that port. She was completely fitted for carrying mounted troops, had shingle ballast, a crew of sixty-five persons all told, no cargo, and no passengers. On being boarded by the Port Health Officer (Dr. W. Peirce, M.D.) all hands were reported well except an A.B., who was thought (there was no surgeon on board) to be suffering from pleurisy. Information having reached the Department of the occurrence of plague at Capetown subsequent to departure thence of the "Antillian," the ship was at once placed under fumigation with burning sulphur, and the case of the sick sailor reported. Dr. W. G. Armstrong, M.B., D.P.H. M.O.H., for the combined Metropolitan Districts, was directed to visit the patient; he diagnosed plague (Case I). The vessel was sent to the Maritime Quarantine Station, and the patient was at once transferred to hospital; at the same time inoculation was offered to all hands, but only ten (mostly officers) accepted, though at later dates a few more were done.

51. The following account of Case I, prior to March 2nd, was taken from the ship's log; the remainder was furnished by Dr. Armstrong:—

Case I.—O. O., Norwegian, aged 19; a deck hand, not inoculated; spoke very little English; was reported to have been quite well until—

February 27th.—Complained of frontal headache and chilliness; he vomited several times after taking a little food, but had no persistent vomiting. At 4 p.m., temperature 101°; began to feel pain in right axilla during the evening; took aperient medicine, which acted freely.

February 28th.—8 a.m., temperature 99·2°; midday, 101°; 8 p.m., 103°. There was a swelling in the axilla which increased in size during this day.

March 1st.—8 a.m., temperature 100°; midday, 101°; 8 p.m., 103°. The swelling was poulticed.

March 2nd.—Was found lying in his bunk in the forecastle. Face flushed, conjunctivae injected; tongue slightly furred; temperature 104·8°, p. 120, merely febrile in character and without tendency to dicrotism. There is a large œdematous swelling in the right axilla, which extends downwards to about six inches below the anterior fold of the axilla, along the wall of the chest. In the upper and anterior part of the swelling is a well-defined hardness about the size of a walnut, situated beneath the *pectoralis major*. The whole of the swelling is very tender, but the hard portion especially so. The lymphatic gland above the inner condyle of the right humerus is swollen to the size of a hazelnut, reddened and tender. An enlarged and tender gland can be felt below the angle of the jaw on both sides. There are neither wounds nor excoriations on the right side of the body.

March 3rd.—Died during the afternoon.

52. On *March 2nd* Dr. Armstrong, after disinfecting the skin thoroughly, abstracted liquid with a sterile hypodermic needle from the deep hardened area in the axillary swelling, and from the enlarged supratrochlear gland. At the laboratory this was subjected to microscopical, cultural, and inoculation tests of exactly the same kind as those already fully described (Report, 1900, Appendix A). It was found to contain numerous bacilli easily recognisable as *b. pestis*; and they proved fatally and characteristically pathogenic for two guineapigs into which some of the liquid was injected.

53. The following account of a second case has been abstracted from the clinical record kept by Dr. A. E. Salter, in medical charge of the Quarantine Station:—

Case II.—W. J. W., aet. 23, storekeeper; not inoculated. During the night of *March 11th–12th* felt some stiffness or soreness about the right groin, which he supposed was due to strain.

March 12th.—On examination, one gland of the left femoral chain was found to be enlarged, hard, tender, and distinct; temperature normal; no constitutional symptoms. Has had several attacks of malarial fever during past years. Isolated for observation.

March 13th.—Had been delirious during the night, and had not slept. State of the enlarged gland unchanged; no periadenitic effusion. Temperature, 103°; pulse, 104; respiration, 28. Transferred to hospital. At midday 60 cc. of Yersin serum were injected subcutaneously; 40 cc. in the left, and 20 cc. in the right thigh. At 1·45 p.m. had a rigor; temperature, 107°. At 8·45 p.m. an attempt was made to inject 40 cc. of serum into the right median basilic vein, but only 10 cc. could be made to enter; the remainder was injected under the skin of the right flank. On this date the patient was visited by the Assistant Medical Officer of the Government (Dr. R. J. Millard, M.B., D.P.H.), and by Dr. Armstrong. Smears were made, and culture tubes inoculated, with liquid withdrawn from the bubo; the former showed a pleomorphic bacillus in large numbers which resembled *b. pestis*, while the latter

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in due course yielded pure cultivations of *b. pestis*. It was not thought necessary to apply any inoculation test to this bacillus, the clinical features of the case and the surrounding circumstances having already rendered the nature of the illness certain.

March 14th.—Had slept fairly well. Temperature, 99·8° morning, rising to 103° evening; eyes suffused; severe headache. At 10 a.m. 40 cc. of Yersin serum were injected under the skin of the right thigh; at 5 p.m. 40 cc. under skin of left calf.

March 15th.—Had slept better; urine offensive; bubo very painful; morning temperature, 99°; rising to 102·4° at night.

March 21st.—Has progressed favourably during the past week. On this date a profuse urticarial rash appeared, attended with much itching, &c.; temperature rose to 103·4°. The bubo was incised, giving exit to from 8 to 10 cc. of lumpy pus, and revealing a deep but not extensive cavity.

March 22nd.—The rash and irritation continue; very little discharge from bubo; was delirous all night.

March 31st.—A slough was discharged from the bubo; entered on convalescence.

54. On March 2nd Dr. Armstrong secured and carried to the Laboratories the putrid carcase of a rat (No. 1) found on board the "Antillian." On the whole this turned out to be too much decomposed for profitable examination; however, smears made from the inguinal glands revealed a bacillus resembling *b. pestis*, but cultures made from them and from other organs became overgrown in eighteen hours. On March 4th, the bodies of two more rats, which had been found dead on the "Antillian," were received.

55. Rat No. 2.—The skin showed very numerous petechial hæmorrhages, the abdominal cavity was full of blood-stained liquid; the liver was enlarged, soft, and full of punctate hæmorrhages; the spleen was enlarged, congested, and necrosed in one or two rather large patches; there were hæmorrhages in the kidneys and adrenals; the lungs were inflamed and blood-full. Smear preparations made from liver, lungs, spleen, and inguinal glands teemed with *b. pestis*, and pure cultures were recovered from all these organs. A guinea-pig inoculated in the right thigh with material from the liver of rat No. 2 died in seven days, and presented the appearances usual in inoculated plague; smear preparations made from its various organs revealed *b. pestis* in profusion, and pure cultures of *b. pestis* were recovered from the latter.

56. Rat No. 3.—The body of this animal presented exactly the same appearances as have been described above of rat No. 2, and direct and cultural tests yielded similar results. No inoculation tests were made, the nature of the disease being already unmistakable.

57. The master of the "Antillian," who took a lively and intelligent interest in the infection of his vessel, said that there were not many rats on board; but that, on the day of departure from Albany (February 22nd), some unusual, though not great, mortality was discovered among them in the course of cleansing operations, about fifteen carcases having been found and thrown overboard. He also said there were several good ratting cats on board, and that whereas these cats had occasionally brought rats they had caught to the bridge for inspection, after the above-mentioned mortality had been noticed they caught (or, at all events, exhibited) no more.

58. After leaving Albany all the deck hands (sixteen) except the quartermasters were employed in cleansing the holds under supervision of the mate and the boatswain; the log showed that all hands had been thus employed on February 22nd, 23rd, 25th, and 26th, but the work was continued in some degree almost until Sydney was reached (March 2nd). It was during these operations that the fifteen dead rats mentioned above were found. The sailors would not touch them—not because any danger was apprehended, it was said, but because they thought it was "not their work" to handle dead rats—and they were thrown overboard by the mate and the boatswain (neither of whom fell ill). O. O. was one of the sixteen deck hands, and was employed with them on the work just mentioned.

59. It has been mentioned already that the "Antillian" arrived completely fitted for carrying mounted troops, without any cargo or fodder, and in shingle ballast. But she brought a quite small quantity of food stores—biscuits, tea, confectionery, sugar, flour, &c., &c., all of which except 7 tons was securely cased. These stores were in charge of W. J. W., Case II, and they were stowed on the orlop deck in the most forward of the five compartments into which the hull was divided by water-tight and fixed bulk-heads. Below this part of the orlop deck a small

small quantity of dried potatoes was stowed, but the other stores mentioned were parcelled out among several rooms temporarily constructed on the orlop deck. During the cleansing already mentioned these store-rooms were not touched.

60. The ship brought a clean bill of health issued to her at Capetown, and in answer to the usual questions her Master stated that neither plague nor any other epidemical disease existed there at the date of his departure (February 1st). But on February 12th news had reached the Department of the occurrence of plague in man at Capetown, two cases having been reported under date February 9th, and on the same date it was also reported that the dock rats had migrated from the South Arm of Capetown docks and had made their way to Green Point Camp. In view of these reports the "Antillian" had been placed under fumigation with sulphur almost immediately on arrival, and before the nature of O.O.'s illness was suspected. After the latter had been clinically recognised she was submitted to a second fumigation, which began on March 3rd, and continued till the morning of March 4th. Neither of these fumigations can have much affected the store-rooms, since these were separately built up within the forward compartment. On March 5th the store-rooms were inspected preliminary to directing special disinfection, and the carcases of one putrid and one desiccated rat were then found. The rooms and their contents were thoroughly sprayed with sublimate solution 1-500 by the Quarantine staff, and afterwards were fumigated with burning sulphur. On March 9th, the stores were transferred to a lighter under superintendence of W. J. W., Case II (when ten more carcases were found), so that the rooms might be more thoroughly cleaned; and this having been done, they were replaced on March 11th—again, under supervision of W. J. W. The latter, who had not been on board except on the dates mentioned, fell ill during the night of March 11th-12th; it is, therefore, most probable that he was infected on March 8th, during removal of the stores, this having been the third day before attack. Several other persons were engaged in this work, none of whom fell ill.

61. The previous history of the "Antillian" was compiled from the ship's logs, and was as follows. The "Antillian" left Southampton towards the end of 1899, and arrived at Capetown during the month of December. She remained on the South African Coast about seven months, going backwards and forwards between Capetown and Durban; she lay in the stream at the latter port, and usually lay alongside at Capetown. On July 23rd, 1900, she left Capetown for Hongkong, *via* Singapore. She reached Hongkong August 22nd, 1900, and lay in the stream; she discharged ammunition and received coal and stores, but did not go alongside there. On August 26th, 1900, she left Hongkong for Wei-hai-wei, where she arrived August 30th; she lay in the stream. She left Wei-hai-wei October 26th, 1900, and arrived at Woosung, October 28th; left Woosung, October 29th, and arrived at Hongkong November 1st. She lay in the stream at first, but afterwards went into dock at Kowloon. She left the latter berth and cleared for Durban on November 7th, 1900. Her further history is tabulated below:—

Left.	*Arrived.*
1900.	1900.
Kowloon Dock, November 7th	Durban, December 3rd; lay in the stream.
Durban, December 7th.....	Capetown, December 10th; lay alongside at South Arm.
South Arm, December 14th.....	Graving Dock, December 14th.
Graving Dock, December 21st..... ..	Coaling Wharf, December 21st.
Coaling Wharf, December 24th	Anchorage in stream, December 24th.
Anchorage in stream, December 27th ...	South Arm, December 27th; lay alongside.
1901.	1901.
South Arm, January 4th	Anchorage in stream, January 4th.
Anchorage in stream, January 11th	South Arm, January 11th; lay alongside.
South Arm, January 12th	Port Elizabeth, January 14th; anchored in stream.
Port Elizabeth, January 14th.....	East London, January 15th.
East London, January 16th.....	Durban, January 17th; anchored in stream.
Durban, January 19th	Capetown, January 23rd; anchored in stream.
Anchorage in stream, January 29th	South Arm, January 29th; lay outside the s.s. "Juanita North," across which vessel traffic with the shore was carried on.
South Arm, January 31st	Coaling Wharf, January 31st.
Coaling Wharf, February 1st	South Arm, February 1st; lay alongside.
South Arm, February 1st	Albany, W.A., February 20th; anchored in stream; took coal from a lighter.
Albany, February 22nd	Sydney, March 2nd; was arrested at the Boarding-station.

62. There is no reason for referring further to any of the ports touched by the "Antillian" during the fourteen or fifteen months which preceded the date of her departure from Capetown for Australia; there is an apparent possibility of her having acquired the infection of plague, but nothing occurred during her second term of service on the South African coast (of three months) to raise a suspicion that she actually had done so. On the other hand, although at the date she left Capetown that port was not known to be infected with plague, remarks published by the Director of the Bacteriological Institute, Cape Colony (Dr. A. Edington),* leave no room for doubt that the rats infesting the South Arm of the Capetown docks had been dying of some epizoötic disease before February 5th; and, since the prevalence of disease among them had become known by that date at latest, it is almost certain that they had begun to suffer at least a fortnight or three weeks before. Now, from the log of the "Antillian" it appears that this vessel had lain alongside at South Arm during 1901 on January 11th, January 20th, and February 1st.†

63. The "Antillian" lay at Albany for twenty-four hours on February 21st and 22nd; she anchored in the stream, and received coal from a lighter which came alongside. As plague has occurred in Western Australia it is necessary to point out that the first case in that State in 1901 (but see Table VII, p. 11) was notified on March 1st, and was that of a man who had died at Perth—that is to say, this death occurred five or six days after the "Antillian" had left Albany. The latter is not near Perth; it is a small town on King George's Sound where there is an excellent harbour, and lies 245 miles south-east of Perth, with which, however, it is connected by rail. Other cases subsequently occurred at Perth, and more at some other towns; but no suspicion of plague has ever attached to Albany either in its people or in its rats; it has already been noted above that mortality among the ship's rats was discovered on the day of departure from this port.

64. The "Antillian" was returned to service 13 days after her arrest‡; and 35 days after arrest sailed for Capetown, carrying 527 troops and their horses. No suspicious illness occurred on the voyage. She is the only vessel entering the port of Sydney on which either plague-rats or cases of plague in man have been discovered.‡

65. But the mode in which plague is diffused by sea is not always as clearly demonstrable as in the foregoing instance; and this the following case well exemplifies.

The Case of the Barque "Eulomene" (Case 72).

66. The four-masted barque "Eulomene" left Liverpool October 12th, 1901, carrying a crew of 34, and a general cargo. She arrived at Sydney January 15th, 1902 (Case 4), and reported one death from dropsy during the voyage; she was admitted to pratique the same day. She lay in the stream until January 21st, when she went alongside Federal Wharf and discharged cargo; 800 tons, consigned to Newcastle, were retained on board. On February 26th she left Federal Wharf and lay in the stream till March 6th (Case 49).

67. Rats from Federal Wharf had been examined in the laboratories on November 22nd and 23rd, and from Federal Bond on November 23rd, 25th, 26th, and 28th, 1901; between March 5th and April 15th, 1902, 186 rats were collected on the wharf on 25 days, of which 45 were examined in the laboratories; in all cases the result was negative, and there was no history of unusual mortality among the rats at this wharf.

68.

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* The *Lancet*, June 8th, 1901.

† It is necessary to note here that Dr. Edington did not succeed in collecting any rats at South Arm docks for six days after the search commenced; that the carcase of a rat which had recently died was delivered to him on the seventh day; that he found that this rat had died of an infective disease; and that while he was unable to name this disease he considered it was not plague. Manifestly little importance attaches to this failure to identify disease in a single carcase.

‡ Contrary statements contained in the Local Government Board's "Reports and Papers on Bubonic Plague, 1902," are erroneous.

68. On March 6th, before her departure for Newcastle, the vessel was handed over to the Fumigating Staff, under Captain Tait, in accordance with the Order in Council of November 21st, 1901; it was subsequently reported that this fumigation was very thorough, and that after being detained not less than six hours under sulphur, she had sailed. The hatches were opened at sea, and the holds were searched for dead rats as soon as they could be entered by the crew; the Master said that many fresh carcases were found, as well as some rats which were alive, but stupefied; altogether about 40 were thrown overboard. On arrival at Newcastle, on March 7th, the "Eulomene" went straight to the Dyke and shipped 500 tons of coal; on March 8th she went alongside at Queen's Wharf and discharged the 800 tons of cargo; she left Queen's Wharf March 20th and made fast to No. 1 Dolphin, Stockton.

69. On March 17th (or ten days after arrival) F. J., 43, ship's steward, was taken ill, and was attended on board by a private practitioner, under whose direction he was removed to the general hospital on shore. On March 19th his case was reported as suspicious, and the Medical Officer of Health for the Hunter River Combined Districts (Dr. Robert Dick, M.B., D.P.H.) was directed to examine him. On the 20th Dr. Dick reported that smears made with liquid withdrawn from the right axillary bubo which the patient exhibited showed a few micro-organisms resembling *b. pestis*, and that agar-tubes inoculated with the same liquid had yielded pure cultures of *b. pestis*, after 24 hours' incubation; he subsequently further reported that a guinea-pig inoculated with the liquid had died of plague, as ascertained by the usual processes. These results, at Dr. Dick's request, were checked, as far as possible, and were confirmed, in the Departmental laboratories.

70. The Port Health Officer (Dr. R. U. Russell) was at once directed to place the vessel in quarantine, and to cause her crew (who on her arrival at Newcastle numbered 22) to be collected on board with assistance of the Water Police; on the 21st she hauled off into the stream. A further fumigation with sulphur was carried out, and a very thorough search for rats afterwards made by the Quarantine Staff, under Dr. Russell's supervision. About 20 desiccated carcases were found, but only two recently dead rats and one mouse; the latter were examined by Dr. Dick and furnished no evidence of plague. All on board remained in good health, and after 5 days detention the "Eulomene" was admitted to pratique. At the same time the 800 tons of cargo landed at Newcastle were traced to various bonds and stores, some in towns at a considerable distance; they consisted of cases of hardware, crates and casks of earthenware, cases of whisky and beer, bales of paper and of other such goods, many of which were likely to harbour rats. It was found that some of these packages had been opened already; others were opened with precautions, under supervision, but it was reported that no rats were found in any instance.

71. In the meantime the patient had been removed from the general hospital to the Maritime Quarantine Station at Stockton. His illness was not very severe, and he was able to give the following information which, on the whole, was corroborated by enquiry of the Master and some members of the crew. He said that while the ship lay at Sydney fresh meat and vegetables were furnished by a ship's butcher in Erskine-street. A bag or two of potatoes were supplied at a time, and were kept on board in his store; on several occasions, on putting his hand into the bags, he encountered rats which were stupid or sluggish, so that he had had no difficulty in destroying them, and had not been bitten by them. He said he had thus found 6 rats at least, on different occasions, and for the last time some few days before leaving Sydney. On being questioned the butcher admitted that he had got some of the potatoes at all events (he was reluctant to furnish information) from a produce salesman trading at Nos. 61–63 Sussex-street. At this store no plague rats had been found, and no case of plague had occurred; but at No. 41 (ten doors away) plague rats were got on February 18, 19, and 20; at the Union Company's wharf on February 19; at the North Coast Co.'s wharf on February 25; dead rats had been seen by officers of the Department at Campbell's produce store, 49–51 Sussex-street, and Case 42 occurred in a man employed there as a carter, who was attacked February 27; and plague rats had been got from Huddart, Parker, and Co.'s wharf on February 28: all of these premises being close together on the same side

side of Sussex-street—that is to say, on the eastern side of Darling Harbour—as the premises of the produce salesman who sold the potatoes to the ship-butcher, who supplied them to the "Eulomene" while she lay at Sydney.

72. The above are the facts of this case, as far as they could be ascertained; they must not be taken for more than they are worth. For instance, it is quite possible that at some time or other before March 5, during the "Eulomene's" stay there, the Federal Wharf may have harboured plague rats, of which specimens were secured from other wharves at no great distance. The ship's rats may also have become infected during her long stay at a wharf in an infected neighbourhood in other ways, as exemplified by the steward's account, which latter seemed trustworthy as regarded the important points. Secondly, after the first fumigation at Newcastle, twenty desiccated carcases of rats were found. Now these carcases hardly could have been killed by the first fumigation (March 6), because the interval between it and the date on which they were discovered (March 22) was not long enough for desiccation, or, as it was described, mummification. Did these desiccated carcases represent the result of a foregoing epizoötic which occurred while the ship lay at Sydney, or did they represent merely the turning out of gradually accumulated carcases from parts of the ship rarely cleansed? There is no reason to doubt that the two rats and one mouse found after the second fumigation represented all that the ship then carried alive; both the fumigation and the subsequent search were most thoroughly carried out, and the result was accepted as proof that she was not then infected, so that she was forthwith released from quarantine. The fact that one only of the twenty-three persons on board was attacked is not evidence that the vessel had not been the subject of general infection; our experience has shown that when the infection is present, as proved by the occurrence of one case, very often no further cases occur. But the one person infected in this instance was the steward, and according to his account he had been specially exposed. Was he infected directly from the sick rats he took out of the potato bags? This cannot have been the case, because he was not attacked until ten days after he had left Sydney, and the last occasion on which he had caught a rat was several days, as he said, before leaving. For similar reasons he cannot have been otherwise infected at Sydney, for he had not been ashore there for nine days before he arrived at Newcastle, or nineteen days before his attack; and he was not infected on shore during his stay at Newcastle, because there had never been plague there, and the solitary case which afterwards occurred under circumstances which require separate description, was not attacked until August 7, or about five months afterwards (see page 49). He must have been infected on board his ship; and, as he exhibited a bubo, he was infected by inoculation; that being so, it is unlikely that he received the infection earlier than March 14, or three days before his attack. Whence was he inoculated? The choice seems to lie between contact with deposited infection and inoculation by a parasite. As to the first, the infection might possibly have been deposited by the sick rats he caught; but in that case it must have survived in virulent form for ten days at the least, or for about fifteen days (namely, from the date of the ship's departure from Sydney, or from that date a few days earlier on which he had seen the last of the sick rats); besides which the cuticle of the extremity had not recently been broken (see Further Observations on the Mode of Infection, p. 65). Certainty cannot be reached—I may almost add, of course; for although epidemiological problems are resolved by induction from collected cases, it often happens to be impossible to show that a particular instance exemplifies the solution. I conclude, therefore, by pointing out that these notes suggest an analogy with certain occurrences of yellow fever on board ships.

73. The "Eulomene" sailed from Newcastle for San Francisco, where she arrived July 24. A rumour was heard that her master was ill on arrival, and subsequently died, of plague. By favour of the United States Consul the Medical Officer of Health received a copy of a report made on the case to Surgeon-General Wyman, Public Health and Marine Hospital Service of the United States, in which it was clearly shown that the disease was beri-beri, and that there had not been any suspicious illness of any character during the voyage of the vessel to that port.

Part II.—Mode of Spread.

Subdivision of the affected district into Areas.

74. I now enter on a description of the mode in which the epidemic spread. This has been designed so as to place the reader in the same position as those who watched the events as they occurred from day to day, as far as possible; and, in order to make it more easy to grasp, the parts of the city in which indigenous cases of plague were met with have been divided into areas, to which the following names have been given (see Diagram II) :—

Area.	Area.	Area.
South-central.	Central.	North-central.
Paddington.	Darling Harbour.	South-west-central.
Chippendale.	Woolloomooloo.	South-east-central.
Alexandria and Waterloo.	Camperdown.	Pyrmont.

75. As a rule, the description of the epidemic on each area dealt with has been completed, a plan which has obvious drawbacks; but the alternative, which is to describe the cases in their time-relation, could lead to nothing but confusion, and may be dismissed as impracticable. The description of the South-central area alone has been interrupted to admit that of the sub-epidemic on the Paddington area. No "area" has been assigned to 4 isolated cases which are adjudged to have been infected at 4 widely separated places.

76. To describe all the cases, and even all the areas, would involve a good deal of repetition owing to general similarity of the facts; some have therefore been selected. They constitute a large majority; but, in an inquiry of this kind, it is important that the reader should have some means of judging whether anything of real importance has been omitted. For this reason a Table has been inserted in the Appendix, in which every case is mentioned under its serial number, and a reference given to some of the paragraphs in which those which have been described may be found. This Table also shows the date of attack in each case, the 86 adjudged places of infection for 113 of them (that is to say, the number which remains after 1 case excepted, and 25 cases in which the place of infection remained undetermined, have been deducted from the 139 cases in which the epidemic consisted), and the area within which 82 of those places stood (see par. 75, end).

South-central Area.

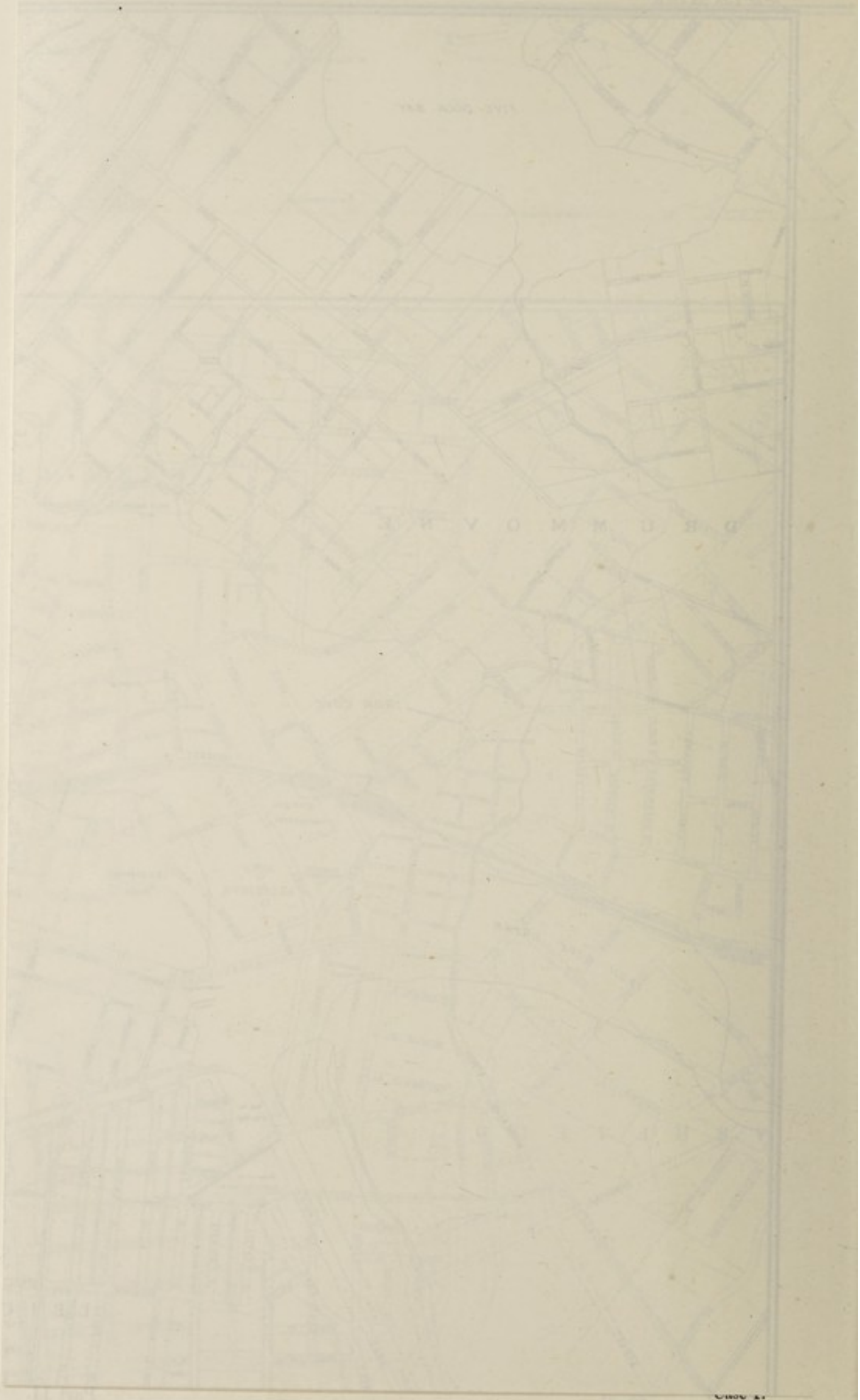
77. The following Table shows the cases which occurred on this area :—

Table IX.—Showing the serial number, date of attack, adjudged place of infection, and residence of the 8 cases which occurred on the South-central Area.

Serial No.	Date of attack.	Adjudged place of infection.	Residence.
1	Nov. 4, 1901 ..	Exton's Store, Hay-street ...	Alexandria.
4	Jan. 12, 1902 ..	285, Castlereagh-street ...	The same.
16	Feb. 9, 1902 ...	376, Pitt-street	„
93	April 3, 1902 ..	137, Liverpool-street	Marrickville.
112	„ 27, 1902 ...	26, Campbell-street	The same.
113	„ 30, 1902 ...	59, Goulburn-street	„
117	May 3, 1902 ...	26, Campbell-street	„
126	„ 15, 1902 ..	26, Campbell-street	„

"DIAGRAM II"


PREPARED FOR THE DEPARTMENT OF PUBLIC HEALTH
MAP OF THE
CITY OF SYDNEY
AND
ADJACENT MUNICIPALITIES.
1903
THIS DIAGRAM SHOWS THE ADJUDGED PLACES OF INFECTION FOR 113 CASES OF PLAGUE, BY 86 BLUE SPOTS. IT ALSO SHOWS THE ARBITRARY BOUNDARIES OF THE AREAS WHICH, FOR CONVENIENCE OF DESCRIPTION, HAVE BEEN ASSIGNED TO THE DIFFERENT NEIGHBOURHOODS IN WHICH THOSE PLACES STAND, BY BROKEN BLUE LINES.
DRUMMOYNE
NORTH CENTRAL AREA
DARLING HARBOUR AREA
CENTRAL AREA
SOUTH WEST CENTRAL AREA
SOUTH CENTRAL AREA
SYDNEY
LEICHHARDT
ANNANDALE
PETERSHAM
CAMPERDOWN
DARLINGTON
PHILIP PENDALE
ALEXANDRIA & WATERLOO
MARRICKVILLE
ALEXANDRIA



Case 1.—R.B., m., aged 17, not inoculated, was suddenly attacked with headache and rigors after reaching his place of employment on the morning of 4th November, 1901. He immediately returned to his residence, and lay there under care of his club surgeon until 8th November; he was then transferred to Prince Alfred Hospital. His case was reported to the Department on 14th November; he was visited by the Assistant Medical Officer of the Government (Dr. R. J. Millard, M.B., D.P.H.), and was removed to isolation the same day. His removal was determined by purely clinical considerations, for the morphological test which was applied to liquid abstracted from the right femoral bubo he exhibited failed to reveal the bacillus of plague; but the cultural and inoculation tests which were begun at the same time yielded positive results in due course. Ultimately the patient recovered.

78. R.B. resided with his family of 6 persons in a two-storied brick cottage at Alexandria, some 2 miles away from his place of employment. These premises were very carefully examined on the day his case was reported, but nothing of importance was discovered; they were in fair general repair, maintained in average good order, and furnished no evidence at all of infestation with rats. No illness occurred among the rest of the household. He was employed, along with three other men, at a produce store in Hay-street, in the City of Sydney, which will be further referred to as "Exton's store," and these premises were also examined as soon as attention had been directed to them by his case. They were found to be one of 13 houses on the frontages of a very small block which was occupied in large proportion by gasometers, the extensive and lofty building of a "universal provider," and a church. Eleven of them were used as produce stores, one was a seedsman's, and one a small hardware store; that is to say, they were chiefly used in ways most likely to attract rats to them. They had behind them a small common yard, in which four of these traders, who were Chinese, had erected stables and feed-rooms. Exton's premises were in fairly good repair, but offered abundant evidence of infestation with rats; and on raising the wooden floor 69 carcases were found. Of these 68 were too putrid for any useful examination, but one was quite fresh; it afforded the usual microscopical, cultural, and inoculation evidence of plague. This animal, then, had lately died of plague; and it is a very reasonable assumption that the other 68 had also died of that disease at somewhat earlier dates. No case of plague occurred among R. B.'s 3 fellow-labourers at the store, and none was heard of among the persons who had frequented it, for no further case came to notice during the ensuing 5 weeks.

79. The cleansing-staff immediately went through the block, and in the course of their work discovered 18 more putrid carcases. These are said to have been found outside buildings, for the most part, at least, but no note on this point was made at the time. No other of these houses, however, afforded evidence either of such infestation as was discovered at Exton's, or of any unusual mortality. There are here three noteworthy points: Our general experience as far as it has gone shows that only a moderate or even small proportion of adjacent premises may be infested with rats (apart from question of plague) although from their structural state and use nearly all of them appear equally likely to be so; of which a further and detailed instance will be given below. Further, it appears that often the epizoötic is largely confined to the rats inhabiting particular premises, and at any one time probably affects but a small proportion of the total rats in the district. Secondly, from both epidemics we have evidence of establishment of centres of infection by a mode of transportation from the local *fons et origo* which does not cause infection of the traversed interval, and of slow and irregular spread of the epizoötic from them; while many adjacent buildings might at the same time harbour a plague-stricken horde, on the whole this appears to be seldom the case. Lastly, it will be observed that but one carcase was found which was in a state to admit of its bacteriological examination; all the others were advanced in putrefaction. Our general experience is that while dead rats are often found in a number which indicates some unusual cause of the mortality on premises to which attention has been directed by occurrence of a case of plague in man, it is quite unusual to find them early enough to allow of demonstration of the nature of the disease of which they have died. We have been led by observation to consider that discovery of several carcases at about the same stage of putrefaction on premises where poison has not been laid, is good evidence of disease in epizoötic form.

80. Efforts were also made at once to ascertain the provenance of Exton's stock, and steps were taken to re-organise a rat-catching staff. As to the former, it was said that some of it came in by rail from country districts in this State where, of course,

course, there was no plague; but the greater part came in by sea, and was landed at the wharfs where this trade is chiefly carried on, those, namely, on the eastern shore of Darling Harbour. This portion chiefly arrived from South Australia, Tasmania, &c., &c., and it was said that none had been received by him from Queensland.

81. The rat-catchers got to work on 10th November, and on 17th November they made their first return. They were instructed to attach the addresses at which they had caught the rats to the carcases, and to hand them in to a foreman, who recorded them, each morning. This staff was further instructed to forward to the laboratory the bodies of all rats apparently sick on discovery, and the bodies of all which were gathered on premises where there had been unusual mortality among them. Carcases thus selected were examined in the laboratory; but the method of selection was imperfect. It was not until 1st April that all rats taken by this staff were handed in at the laboratory and systematically examined there.

82. The neighbourhoods in which the staff worked during the days now under notice were the line of wharves already mentioned, the buildings from the head of Darling Harbour towards Exton's store, from the latter westerly along George-street, and additionally along the line of that gutter or natural surface depression which ascends from George-street in a southerly direction to the Newtown-road. To speak for the present of the first 10 days of this search only, 1,657 rats were caught at 28 wharfs, and at 115 different premises, which included many produce stores, hotels, eating-houses, and provision shops, on or about the line above indicated; 117 were selected and were forwarded to the laboratory. Thus the rats on the area which there was most reason to suspect (in part from our former experience) were examined. It would have been better had all those caught been delivered at the laboratory; but it must be remembered that had this course been taken, the examination would not (and it never could) have amounted to more than a sampling—to examination, that is, of the rats in some of the innumerable houses which stood on the area referred to. Further, selection of the buildings visited was largely governed by willingness of the occupants to admit the rat-catchers at night.

83. On the second day (18th November) of the search a plague-rat was detected among those referred to the laboratory. It had been collected at Howard Smith & Co.'s wharfs, and at that one of them which is called the Brisbane Wharf (see par. 49), although it is understood not to be exclusively used by those vessels of this firm's fleet which trade between Sydney and Brisbane; they are wharves at which much grain and produce are handled, and adjoin those wharves at which Exton's stock in part was landed—the detected infection of this Brisbane wharf betokening, of course, probable infection of other wharfs in its immediate neighbourhood.

84. No other plague-rat was found until the ninth day of search (25th November). A second produce dealer, named Jones, then reported that the rats which infested his premises at 84, George-street West (about 45 chains westerly from Exton's) were dying in numbers. The store was at once closed and searched; no less than 154 carcases were discovered, and 35 living rats were killed. Here, it seems, the search was made quite early in the outbreak, and before the animals had recognised the expediency of leaving the premises; and it was easy to demonstrate that plague was the cause of the mortality. No case of plague occurred among the persons employed or living at this shop nor, it is believed, among those who must have frequented it. Then on the tenth day of search (November 26) a plague-rat was handed in by the Departmental staff, which had been taken on premises at the corner of Cleveland and Abercrombie streets, towards the head of the surface-depression already referred to, and about 22 chains southerly from Jones' store. They included a greengrocer's shop and a stable. There were abundant signs of recent infestation by rats in considerable number, but no carcases were discovered nor any live rats. It was noted that the premises were filthy, the yards being largely occupied by fowls, ducks, geese, and dogs. A ton of chaff, bones, and rat-rubbish was removed from under the floor of the feed-room, and the whole premises were in such a state of dilapidation that the Local Authority was required to apply for a closing order and for their demolition. No

case

case of plague occurred among the persons inhabiting these premises, nor among any casually connected with them as far as could be learned. No note was made as to the source at which horse-feed was procured; this may have been Jones' store, which was but a little over a quarter of a mile away.

85. Laboratory examination of rats continued in a manner which will be summarised and commented upon at a convenient place in this description, without revealing any others infected with plague, until the next case in man had occurred about five weeks later.

Case 2.—J.E.D., m., aged 37; had been inoculated at Rockhampton, Queensland, early in 1900 (see par. 28); married, four children. He was suddenly attacked on December 8, during the forenoon, with a sharp pain in the left groin, where femoral and inguinal glandular swellings subsequently developed. He lay ill at his residence in Spring-street, Waverley, about 3 miles away from his place of business and the other places hitherto mentioned, under private care until December 10, when his case was notified. The diagnosis was at once made from clinical signs; subsequently morphological, cultural, and inoculation tests all yielded positive results. His condition at the time of discovery forbade removal, and he died December 11 after an illness which had lasted sixty-five hours.

86. J.E.D. was a druggist's assistant. He had arrived from Rockhampton, Queensland, about two months before his death; no case of plague had been notified at Rockhampton for 10 months before his departure (or on 11th October, 1901); his wife said she had received a one pound note from her brother at Rockhampton since her arrival at Sydney, but that deceased had known nothing of it and had not seen it; the case of plague which was notified at Rockhampton next after the one just mentioned was ascribed to 11th February, 1903. His place of residence was in fair general order and repair; it stood in a suburb which has never yielded any other case, and it offered no traces at all of infestation with rats. The family of 6 persons, among whom no illness occurred, was entirely unacquainted with Case 1. He was employed by a firm of wholesale druggists at their premises in the city of Sydney. The firm said that poison had been laid ever since Case 1 had become known, and that 72 carcases had been found and destroyed. A good many more, in advanced stages of putrefaction, were afterwards turned out in course of cleansing, but no live rats were seen, and no evidence of plague was obtained. Such mortality from poison is quite unusual. There were here about 300 workmen, among whom no illness occurred. But D., regularly employed during the day at this establishment, was also employed in the evening by a benefit society, and on this duty he went to the dispensary, which stood in Castlereagh-street, at a point not more than 11 chains distant from Exton's store (Case 1). On examination the dispensary was found to be very well constructed, clean, and free from evidence of infestation with rats; and none of the subsequent cases of plague were traced to connection with it.

Evidence of Diffusion of the Infection.

87. The rat-search continued without revealing any plague-infection until after a further interval of thirty-five days. The third and fourth cases in man happened on January 10 or 11 and on January 12. The former was the first of a sub-epidemic which occurred on what has already been referred to as the Paddington area; the latter was found in the immediate neighbourhood of the dispensary building mentioned in connection with Case 2, and consequently on the South-central area. Cases 3 and 4, therefore, furnished the first clear evidence that the infection had become diffused. The sub-epidemic which followed on Case 3 afforded an unusually distinct (but far from solitary) example of transport of the infection over a considerable tract which either entirely escaped, or suffered only in part at a much later date and, plainly enough, from infection otherwise communicated to it; and I interrupt the account of the South-central area to describe it here, because it was altogether confined to a remote and circumscribed area, and furnishes a most useful type of the course of the epidemic as a whole.

The Paddington Sub-epidemic.

88. The table below shows the serial number, initials, sex, age, date of attack, and address of the patients whose cases constituted this sub-epidemic, as well as particulars concerning two undiagnosed cases which, I have little doubt, were also cases of plague. These latter are unnumbered (see Diagram III).

Table X.—Showing the serial numbers and dates of attack of the nine cases which constituted the Paddington sub epidemic, as well as of two undiagnosed cases connected with them :—

No.	Name.	Sex.	Age.	Date of Attack.	Address.
3	E.A.G. ...	F.	50	January 10 or 11 ...	145, New South Head Road.
...	G.B. ...	M.	35	„ 13 ...	18, South-street, New South Head Road.
...	J.E.G. ...	M.	69	„ 16 ...	35, Gurner-street, Paddington.
5	E.G. ...	F.	21	„ 16 ...	145, New South Head Road.
6	M.C. ...	F.	43	„ 19 ...	147, „ „
7	R.V. ...	F.	10	„ 19 ...	115, „ „
8	J.C. ...	F.	72	„ 20 ...	147, „ „
13	M.A. ...	F.	38	February 7 ...	163, „ „
14	J.H. ...	M.	59	„ 10 ...	192, Albion-street, Surry Hills.
16	J.G. ...	M.	24	„ 10 ...	312, Glenmore-road, New South Head Road.
17	P.B. ...	M.	12	„ 11 ...	217, New South Head Road.

89. These cases came to light in the following way: On 14th January, M. C. (Case 6), who at that date was in apparent good health, reported that rats were dying in numbers at her residence, 147, New South Head Road. Thereupon the rat staff was directed to secure specimens from her cottage and from its immediate neighbourhood. No rats were caught that night, but the rat-catchers reported that the rats were dying at No. 149 (next door) also; it was also mentioned that Nos. 145, 147, and 149 were one-storey brick cottages, identical in construction, and at a later date it was ascertained that the space under the floors of all three was continuous, and open to the rats which infested any one of them. No. 149 stood at the corner of Glenmore-road, and was occupied by R. Goff, junior, as a produce store. He said that the rats on his premises had been dying in numbers for about 10 days past (that is to say, from about 4th January). M. C. said she had seen sick, as well as dead, rats in her kitchen and laundry, and the occupants of all three cottages were at one in saying that although they had formerly been very much troubled with rats, none had been seen alive "for the past few days." On the morning of 16th January, the rat staff handed in one carcase which, on examination, was found to be free from disease; however, they had removed three carcases from the yard of No. 147, and one from No. 145, all too much decomposed for examination, and had noted an extremely offensive smell on all these premises, as though dead rats lay concealed. Lastly, when the premises came to be taken in hand by the disinfecting staff, on 20th January, it was found that, although there were everywhere abundant traces of infestation with rats, there were none pointing to their quite recent presence (fresh dung). Ultimately no plague-rats were taken on these premises, and none were collected from any part of the infected area until many days afterwards.

90. Illness among the inhabitants of these three cottages was first discovered through report, on 19th January, that M. C. (Case 6) was lying ill at No. 147. It was then found that E. A. G. (Case 3) had been attacked eight or nine days earlier, and had been lying in bed at No. 145 in consequence, at the time the rat-search was going on. Comparative mildness of her illness (which, nevertheless, had compelled her to take to bed and to stay there) led to its having been thus concealed, or, rather, not mentioned. E. A. G. (Case 3), having been seized, on 10th or 11th January, E. G. (Case 5), in the same house, was attacked on 16th January, and M. C. (Case 6), in the cottage next door, on the day of notification, 19th January. R. V. (Case 7), who lived fifteen doors away, at No. 115, was attacked on the same date, and J. C. (Case 8) was attacked at No. 147, on 20th January. But there had been two other deaths in connection with these premises, which I have little hesitation in ascribing to plague, although this disease was not recognised as the cause at the time they occurred. The facts were as follows :—

Undiagnosed Case A.—J. E. Goff, senior, age 69, labourer. Was father of J. Goff, of 149, New South Head Road, and regularly worked at the produce store. He resided at a considerable distance away, in a plague-free neighbourhood. He arrived at the store at his usual hour on January 16, having been

been in good health until that date, but complained of feeling unwell; about 10 a.m. his son took him home, and two hours later he died. By direction of the Coroner, his body was inspected by a medical man, who reported that his death was due to syncope from heart disease. I ascertained that this opinion was based on a statement made by deceased's family that he had latterly been breathless on slight exertion, and on observation of slight œdema about the ankles; further, the gentleman referred to, who had both clinical and *post-mortem* experience of plague during the former epidemic, said he thought he could hardly have overlooked the signs of that disease had any of them been present. This may be readily conceded; and yet it appears to me probable that plague in one of its less usual, but not uncommon forms, in which all external signs are wanting, may have been the true cause of death.

Undiagnosed Case B.—G.B., a labourer, aged 35, lived in South-street (see Diagram III). He was an idler who was in the habit of doing odd jobs for R. Goff, junior, and when wanted was usually to be found hanging about the latter's store. He had been drinking from 11th January to 13th January, and thereafter had suffered rather severely from diarrhœa and vomiting. My informant first saw him on 17th January, and then noted a temperature of 102°; dyspnœa, but no physical signs in the lungs; heart's action very irregular, heart sounds feeble, pulse weak; no glandular enlargement; no albumen in urine; a boil on the buttocks. The patient died an hour or two after these notes had been made, and the cause was not assigned to plague at the time; but two or three days afterwards my informant heard of some of the circumstances now being described, and at once revised his opinion.

91. All of these persons were quite unacquainted with Cases 1 and 2, but there had been personal communication after commencement of illness between Cases 3 and 5 and Cases 6 and 8, as well as between the two households. Case 7 was unacquainted with the members of those two households, but was in the habit of visiting Goff's store to make purchases; her parents said that she had last been there "a few days" before she fell ill.

92. An interval of 19 days followed on the attack of Case 8 (20th January) during which no case of plague, nor any which caused suspicion of plague, occurred on this area, (nor, indeed, anywhere else until the seventeenth day); then the case of M.A., housewife, aged 38, was notified the day after her seizure on 7th February; morphological and cultural tests yielded positive results. She lived at 163, New South Head Road, seven doors from the produce store, though, on account of the intervening Glenmore-road, rather further than the space of seven houses away. She had no acquaintance with any of the foregoing patients. She lived in a brick house which was in average condition; but the occupants said that they had been much troubled by rats, and the disinfecting staff reported many rat-holes in the internal woodwork, as well as through the foundation walls, though no live rats nor any carcases were found. But the landlord had already been appealed to on this score, and on 7th February he had caused the ground floor boards to be taken up; quantities of rat-rubbish had been taken from the underspace, as well as two putrid carcases. It is to be noted that a carrier lived next door where he kept two horses. Three days later the following case was notified from a distant neighbourhood:—

Case 14.—J.H., house-painter, aged 59. Suddenly attacked on the morning of 10th February, after going to work, with headache, diarrhœa, abdominal pains, and fever; he exhibited a solitary, left femoral, bubo. Morphological, cultural, and inoculation tests, all yielded positive results. Recovered; duration of illness, thirty-five days.

93. J.H. lived at 192, Albion-street, Surry Hills, about a mile distant from the Paddington area, and in a district from which no cases had been reported for diagnosis. The house was one of a brick terrace; it was in good repair, and well kept; the inhabitants said it had no rats, and the disinfecting staff reported that it was entirely free from traces of infestation. No other case occurred in this household, which consisted of twelve persons. Judged in the usual way, it appeared that J.H.'s residence could not have been the place of his infection. But his occupation led him into other neighbourhoods, and into other premises; and when his movements came to be inquired into it turned out that he was the man whom M.A.'s landlord had employed to raise the floors at 163, New South Head Road, and who had removed the rubbish and the dead rats from beneath them on 7th February. This is a very important and interesting case, to which there will be occasion to refer in another connection; in the meantime it need merely be pointed out that the patient received the infection by inoculation in the left lower extremity, in which there were no visible wounds or abrasions, and that he fell ill a little less than seventy-two hours after he had begun his work at No. 163.

94. The occurrence of Cases 15 and 17 on 10th and 11th February concluded this sub-epidemic; it is not necessary to mention many details of them. J.G. (Case 16) was carter for another produce dealer, and lived quite close to Goff's (see Diagram III);

no

no dead rats were found either at his place of residence or of employment. P.B. (Case 17) was a schoolboy, who lived at a public-house at the corner of Maclean-street. His residence showed the signs of moderate infestation with rats usual on public-house premises, in certain parts of it, and no more; no dead rats were found, nor had the inhabitants seen any; but on 15th February a plague rat was collected from No. 10, Maclean-street, a cottage three or four doors from the public-house. These two patients were said to have had no communication with any of the previously infected households.

95. In order to complete this account it is necessary to review the efforts made to ascertain the state of the area as to infection of its rats. It carried only 163 premises altogether. As has been already mentioned, the rat staff had been directed, on 14th January, that is to say as soon as mortality among the rats which infested Nos. 145 to 149, New South Head Road, had become known, to search those cottages and the immediately adjacent roads, lanes, &c.; and the result had been to show that the rats referred to had suffered from sickness and had died, but had by that time gone away. But the search, which should have extended to slightly more distant streets, was not prosecuted with vigour until after occurrence of Case 17. Thus, down to 12th February only 23 rats, taken on 12 premises, had been brought in; but between that date and 17th February as many as 129 rats were collected by trapping at 60 different premises. The result of this more energetic and more systematic hunt was that on 14th February one plague rat was taken in a builder's yard across New South Head Road, immediately opposite to Goff's store; on the same date another at No. 155, New South Head Road, also a produce store, on the same side as Goff's, but separated from it by Glenmore-road and the premises at the corner opposite to Goff's; while on 15th February a third plague rat was taken, as already noted, at 10 Maclean-street. There is here sufficient evidence of dissemination of the infection of plague among the rats of the neighbourhood; nevertheless I note the infrequency of the disease among the total rats brought in to the laboratory, and reserve this point for the present.

96. The whole of the area affected was taken in hand by the cleansing staff, and thoroughly scavenged, many out-buildings having been pulled down and burnt, and some premises which were unfit for human habitation closed and demolished. The disease did not spread beyond the limits, which include about 16 acres, shown by Diagram III, partly, no doubt, in consequence of the measures taken, but in part also owing to large tracts of park or garden ground, and of vacant lands, by which it was more or less closely bounded to the north and west.

South-Central Area Resumed.

97. We must now return to the South-Central Area, and to Case 4, which was the next to occur upon it.

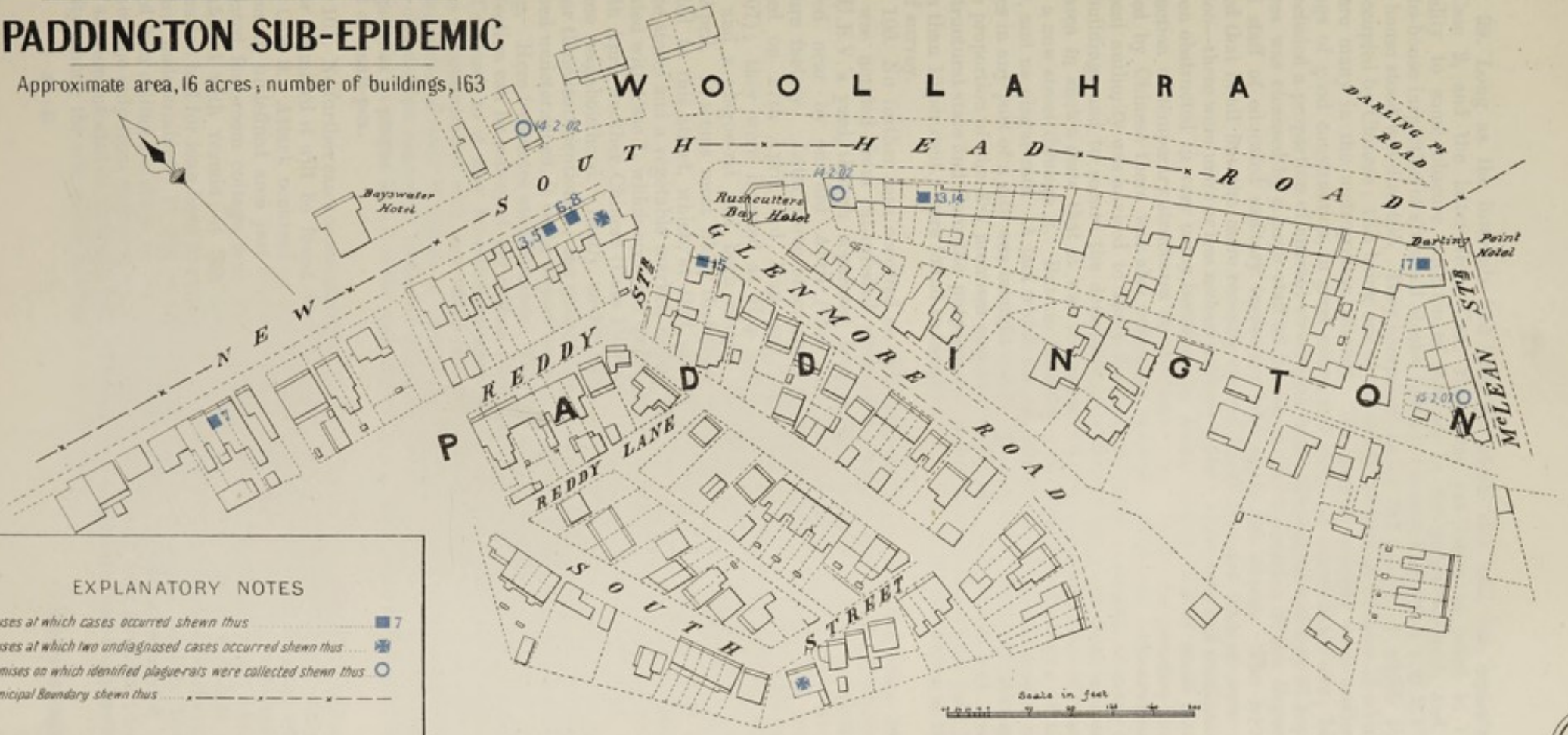
Case 4. V.U.E.V., m., aged 34, a publican, not inoculated, was suddenly attacked during the afternoon of 12th January with shivering, and at the same time discovered a small lump in his right groin, where an inguinal bubo subsequently developed. The morphological test applied to liquid abstracted from the bubo was negative; cultivation and inoculation tests yielded positive results in due course (on the third day of illness this patient's blood was, for some reason, submitted to the same three tests, all of which yielded negative results). Recovered; duration, fifty seven days.

98. The patient was unacquainted with any of the persons previously attacked. He carried on his business at the corner of Goulburn and Castlereagh streets, a point about 2 chains from the dispensary with which Case 2 was connected, and which stood in Castlereagh-street, and about 12 chains from Exton's produce store, where Case 1 had been infected two months earlier. About the beginning of December he had reported to his Local Authority that his premises were infested with rats, and said that soon afterwards he had counted 17 in his kitchen one night; later still he had found a dead rat, and about the same time there had been a very offensive smell, as though dead rats lay concealed, but no more were found. The other residents said at the time of inquiry that the house had been infested shortly before, but that they had seen no rats since the closing of a neighbouring restaurant. The disinfecting staff reported that there were no quite recent traces of infestation, and although traps were set, no rats were caught. There were seven inhabitants, among whom no further illness occurred.

Prepared for the Department of Public Health

PADDINGTON SUB-EPIDEMIC

Approximate area, 16 acres; number of buildings, 163



EXPLANATORY NOTES

- Houses at which cases occurred shewn thus ■ 7
- Houses at which two undiagnosed cases occurred shewn thus ✠
- Premises on which identified plague-rats were collected shewn thus ○
- Municipal Boundary shewn thus x——x——x——

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PADDINGTON SUB-EPIDEMIC

99. Long as the intervals had been by which this case was separated from Case 2, and the latter from Case 1, it was yet taken to point in all probability to some obscure infection of the rats in the neighbourhood, and a house-to-house inspection of six small blocks, towards the centre of which V.U.E.V'.s public house stood was directed. They comprised in all 387 houses, of which 169 were occupied by Chinese; this being one of the small colonies of Chinese of which there are many in the metropolitan district. The greater number were modern buildings of good construction, in good order, and often of considerable size; but they included a proportion of ancient structures, much dilapidated and very ill-kept. The area was cleansed by a large staff of labourers, under direction of the Departmental staff of educated sanitary inspectors who made the survey. The latter reported that in all but the more recently erected buildings—and even on some of them too—there were more or less serious sanitary faults; while light and ventilation had been obstructed in very many instances by illegal roofing over of small yards and erection of temporary structures in the larger ones. When the premises were occupied by Chinese there was also evidence, internally, of serious overcrowding. The local authority was advised to apply for closing orders in respect of many of these buildings and to secure the demolition of some of them; and there was one small area in such a state that it was recommended to acquire possession of it and to run a new street through it. But no illness was discovered in the course of the survey, and no plague-rats. A fact which has importance in relation to general rat searches in any part of a city was brought out by the records; it was, that although a large proportion of the 387 premises appeared to be fit to harbour rats both from their structural state and from the purposes for which they were used, yet only 57 (or less than 15 per cent.) were found to furnish evidence of actual infestation at the time of survey.

100. No further case occurred on this area until 9th February (Case 16), which was notified from rat-infested premises of which the back yard abutted on V.U.E.V.'s yard, though separated from it by a high brick wall. Another occurred near by on 3rd April (Case 93) in a sempstress, employed at a furniture factory. Later, three other cases were met with in Chinese, who were attacked on 27th April, 3rd May, and 15th May (Cases 112, 117, 126—see par. 207); they were infected at Hop Lee & Co.'s produce store in Campbell-street, and a plague-rat had been caught six doors away from Hop Lee's on 22nd April. It seems most likely that these cases resulted from infection newly imported to this street, which, at that end of it, is almost entirely occupied by produce stores and a vegetable market, rather than by persistence of the infection associated with Case 1, which occurred quite close by, but nearly six months before. On 30th April another Chinese (Case 113) was attacked at 59 Goulburn-street, in the same neighbourhood. Lastly, on 1st June, Case 136 occurred on this area, but not near those last-mentioned; the patient was an idler, the place of whose infection remained undetermined, it being almost certain he did not contract his illness at his lodging. Here two notes may be made: The first is that as it has been shown that the infection can be conveyed *per saltum* (most probably to Exton's store, certainly to Goff's store), so it may be communicated to any neighbourhood repeatedly, as long as communication with any other infected spot is maintained. Secondly, in any long series of cases of disease a certain number will be met with in which the source of infection cannot be indicated with any certainty; and this is so far from being peculiar to plague that it is the case even with so easily traceable an infection as that of small-pox.

101. No further cases occurred on the South-central area. If the serial numbers are now examined it will be found that one case has been omitted from notice. This is Case 9. Attack occurred on 4th February; the patient was a newsboy who lived on an undefined area just north of the North-central, where he inhabited a dilapidated four-room cottage, near the northern end of Cumberland-street, which was infested with vermin; it had been infested with rats, but at the date of examination had for long been free from them. The place of this patient's infection remained undetermined; it was merely surmised that he might possibly have received it in calling for stock at the *Evening News* office, which was separated by a narrow lane only from Siddaway's boot factory on the Central area, at which Cases 34 and 43 were infected on 24th and 27th February, and where there was considerable mortality among the rats which infested it (see par. 217).

Chippendale Area.

102. It is necessary here to describe only two of the cases which occurred on the Chippendale area, but the following Table gives a complete list of all of them :—

Table XI.—Showing the serial number, date of attack, adjudged place of infection, and residence, of the eight cases which occurred on the Chippendale area.

Serial No.	Date of attack.	Adjudged place of infection.	Residence.
	1902.		
10	February 5	Sportsman's Arms Hotel, 171 George-street West ...	The same.
12	„ 5	Fish and oyster saloon, 167 George-street West... ...	„
37	„ 20	68 O'Connor-street, Chippendale	„
62	March 16	5 Chambers-street, Ultimo	„
82	„ 21	16 Dick-street, Chippendale	„
92	„ 29	16 Dick-street, Chippendale	„
102	April 18	89A George-street West, City	„
105	„ 20	66 O'Connor-street, Chippendale	„

103. Cases 10 and 12 were attacked on 5th February at 171 and 167, George-street West. These houses were about 11 chains distant from Jones's produce store, and on the opposite side of the road (see par. 84).

Case 10. T.C., potman, aged 42 ; place of residence and of employment, Sportsman's Arms, 171, George-street West. Suddenly attacked 5th February, afternoon ; right femoral bubo ; morphological, cultural, and inoculation tests, positive. Recovered.

Case 12. G.W., a fishmonger, aged 35 ; place of residence and of employment, a fishmonger's shop, 167, George-street West. Attacked 5th February ; right femoral bubo ; morphological test, positive. Recovered.

104. The premises were next door but one to each other, and it will be noticed that both were used in a way likely to attract rats to them. At No. 171, it was said that rats were plentiful both in the neighbourhood and about the public-house itself; but not that there had been any observed mortality among them. The yard was tar-paved and undermined ; part of it was dug up and six putrid carcases were revealed. Three more were found at a gully communicating with an old drain which had not been removed when the premises were connected with new sewers ; from this rat-burrows were traced, and dug out, which ran under the intervening house, No. 169, and passed into No. 167 ; a plague-rat was taken out of them, which was identified in the laboratory on 10th February. The disinfecting staff also killed three rats which were healthy. G.W. (Case 12) was employed and resided at No. 169 ; his house was not noted to have been greatly infested.

Alexandria and Waterloo Area.

105. We now have to describe establishment of another distant, and apparently independent, centre in connection with a fourth produce store (see Diagram IV).

Table XII.—Showing the serial number, date of attack, adjudged place of infection, and place of residence of the eighteen cases which occurred on the Alexandria area.

Serial number.	Date of attack.	Adjudged place of infection.	Residence.
11	February 6	8, Henderson-road	Belmont-street.
35	„ 22	30, Botany-road...	The same.
36	„ 25	68, Botany-road...	„
45	March 1	30, Botany-road...	„
73	„ 19	90, Wyndham-street	„
*79	„ 22	14, John-street	„
90	„ 31	20, John-street	„
98	April 13	1, Bourke-street...	„
107	„ 23	60, Phillip-street	„
109	„ 26	31, Raglan-street	„
115	May 4	Retreat-street, Botany-road ...	„
125	„ 11	Gray's Stables, Waterloo ...	151, Bullanaming-street.
133	„ 28	Grimley's Tannery, Botany-road	105, George-street, Redfern.
132	„ 29	69, Beaumont-street	The same
135	June 5	30, McEvoy-street	„
137	„ 2	77, Cooper-street	„
138	„ 5	17, Botany-street	„
139	„ 8	Louden's boot-factory, Elizabeth-street	54, Morehead-street.

* In Diagram IV this erroneously appears as No. 74.

Case 11. A.H., produce dealer, aged 30; place of residence, Belmont-street, Alexandria; of employment, 8 Henderson-road, Alexandria. Suddenly attacked 7th February, at 7 a.m., with vomiting, headache, and fever; right femoral bubo; both extremities much flea-bitten. Died 12th February.

106. A.H.'s cottage, in Belmont-street, was of weatherboard, in good repair, and clean; it had a stable for three horses in the backyard; the skeletons of three rats were found at the bottom of a dung-heap, but there was no evidence of infestation. The produce store stood close to the Botany-road, at a distance from the cottage of 56 chains. It was also 40 chains from R B.'s residence (Case 1), where that patient had lain ill for the four or five days from 4th to 8th November. It was a wood and iron building, which measured 19 feet by 47 feet; it had a brick front, and was floored with wood. There was a stable in one corner, and the place was dirty and ill-kept. For several weeks before his attack A.H. had not slept at home, but at this store on an extemporised bed of sacks. On taking up the floor the carcases of 39 rats were turned out, all too putrid for laboratory examination, and three healthy rats were killed.

107. Here this account of the beginnings of the epidemic may usefully be interrupted in order to point out that evidence of the dissemination of plague-rats in connection with no less than four produce stores has been adduced, namely, Exton's, Jones's, Goff's, and Huxley's; that bales of hay, &c., are notoriously liable to infestation by rats, which are easily transported in them; and that all four places were almost certainly connected, by the nature of the business carried on at them, with that line of wharfs at which produce is habitually handled, and at one of which a plague-rat was taken almost as soon as the rat search began, namely, on 18th November. We have seen, also, that plague in man occurred in connection with three out of these four stores; and, in the three widely separated neighbourhoods in which they stood, it first occurred in persons connected with the stores either as workmen, or as occupants of adjoining houses in free communication with the store by the space under the joists. Lastly, that the rats were affected before man; this was not demonstrable in Case 1, since the date of notification enabled search to be made only 10 days after attack; but, on the other hand the patient certainly did not infect the rats for reasons already mentioned (par. 77). The evidence on this head relating to Case 3, Paddington area, seems quite clear. Again, it is quite clear in relation to Case 11, for although the search was instituted within 48 hours of the time of attack, all the carcases found were not merely putrid, but too putrid for any useful examination in the laboratory. Later, other instances will be given in which there was no doubt at all that sickness and death of the rats had preceded the first case of illness among the persons inhabiting the premises where the carcases were found; such, for instance, are Group C, Cases 24 and 30, Her Majesty's Theatre and Hotel, and the Criterion Theatre and Hotel (pars. 198, 199, 210 to 216). If Case 1 be excepted, as I do not think it need be, then it can be said that disease in rats preceded disease in man in every case, the evident want of continuity between cases, and the observed establishment of independent centres, being borne in mind. For this discriminative infection of distant spots permits each such occurrence to be considered by itself, and to be regarded as complete in itself. Here, also, the reader will note the absence of infection in man in connection with Jones's store and the house in Cleveland-street; and while this point will be further examined below, the opportunity may be taken of repeating the remark already made (Report 1900, p. 36), that some special condition not usually present seems requisite to secure communication of the infection from rat to man.

108. The large block in which Huxley's store (Case 11) stood was taken in hand by the cleansing staff, but operations within it were not finished for about a month. No plague-rats were discovered in the course of them, nor any other instance of rat mortality. It was not until 21st March, more than a month later, that a plague-rat was collected in that block from the stable of a cabman 6 chains distant from Huxley's store, two days after his son had been attacked with plague (Case 73, the fifth on this area). Other plague-rats were taken later in the neighbourhood: one was identified among many carcases removed from 47, Henderson-road, which was a butcher's shop (see par. 111), and one at each of the houses 14 and 16, Botany-road, on April 8th and 9th, of which one was also used as a butcher's. No case of plague occurred at any of these houses.

109. The second case on this area happened sixteen days after the first in a school-boy (Case 35, attacked February 22nd, removed February 26th; right femoral bubo, recovered) at 30, Botany-road. This house stood north of, and 8 doors from, Henderson-road, and well within a hundred yards of Huxley's store. It was occupied by a pawnbroker, and was in a poor state of repair and maintenance. Floors were lifted, and a great deal of rat-rubbish removed from beneath them; there were holes in them and in skirting-boards, &c., as well as some burrows in the back-yard; no carcases were found and no live rats were seen. But the burrows were not dug out. This was an omission, of which the full significance was not perceived until after the experience gained at the Zoological Garden (see par. 176). It is here pointed out in connection with the occurrence of another case on these premises a week later, and after they had been cleansed and disinfected (Case 45, the fourth on this area, the above-mentioned patient's father, attacked 1st March).

110. The third case (Case 36) happened at 68, Botany-road, the patient, a child, having been attacked 25th February, on which day, also, he died (spleen and bubo yielded *b. pestis* in smears); this house having been on the same side of Botany-road as the last-mentioned, and only 12 doors south of it, though also separated from it by the intervening Henderson-road. It was therefore within a few yards of A.H.'s store. These premises were in very bad repair, and filthy; they were occupied by the patient's father, who was a dealer in bottles and old iron; 10 carcases of rats at about the same stage of putrefaction were removed, together with no less than 36 loads of rubbish and filth, but no plague-rat was identified.

111. The fourth and fifth cases (Cases 45 and 73) have been already mentioned; the sixth (Case 107) happened much later. It occurred in a letter carrier who was attacked on 23rd April. He lived at 60, Phillip-street, in a house which had a stable attached to it. The former was in good order and repair, and the inhabitants said they had no rats; nevertheless on lifting the floor 3 carcases were removed, all of which were too putrid for laboratory examination. This house stood about 15 chains from A.H.'s store. But it was only 6 chains from the shop of one Kerrigan, a butcher, on whose premises a sick rat, which was shown in the laboratory to be suffering from plague, had been taken on March 26th; on cleansing the shop immediately afterwards 80 putrid carcases were removed from the space under its rotten ground floors.

112. Two further cases (Case 115, 4th May, and Case 133, 28th May, being the eleventh and thirteenth on this area) occurred on this, the western side of Botany-road; they were separated from those above-mentioned, not so much in time as by distance. The premises on which they were judged to have been attacked stood 36 chains to the south of Henderson-road (A.H.'s store, &c.), and it is possible that the infection reached them from the eastern side of the road; for further cases had occurred in the immediate neighbourhood of Raglan-street on that side, and had gradually extended in a southerly direction until they had reached land opposite to that on which the houses of Cases 115 and 133 were placed. The series referred to comprised 11 cases (which occurred between Case 79, 22nd March, and Case 138, 8th June). The first two of them occurred in John-street, about 18 chains south-west from Raglan-street; the third, 18 chains further away towards the south; the remainder at various points between those two, and more or less removed from the east side of Botany-road. Case 79, a little girl, of John-street, was attacked (right inguinal bubo) on the third day after she had picked up and thrown out of her garden a dead rat; and on lifting the ground floors of her cottage, four carcases were found. Then Case 98, attacked 13th April at the southernmost extremity of the area, lived eight doors from the Zetland Hotel in Bourke-street, and from stables attached to this hotel a plague-rat was taken on 21st April. So also Case 125 occurred in a man who was attacked 11th May, at his place of employment, Gray's stables, within a short distance of the Zetland Hotel; and on 26th April a plague-rat had been caught at these stables. Sufficient evidence of a dissemination of plague-rats over this infected area was forthcoming, although household connection between diseased rats and the persons attacked was not established in the remainder of this short series.

Prepared for the Department of Public Health

ALEXANDRIA-WATERLOO AREA

Scale of Chains

NOTES

THIS DIAGRAM *shows by blue spots the places at which the 18 cases which constituted this sub-epidemic are adjudged to have received their infection. It shows, also, the places at which identified plague-rats were collected by blue open circles, but not the number of such rats. Blue circles which enclose a cross indicate houses at which persons adjudged to have been infected elsewhere resided, and at which they lay during the earlier days of illness. The numbers are the serial numbers of the cases referred to (for detail see Appendix A.)*

TABLE XIII.—Showing the situation of premises on the Alexandria area at which plague-rats were taken, and the dates on which they were taken.

90, Wyndham-street	March 21.
47, Henderson's-road (Kerrigan's)	March 25.
16, Botany-road	April 8.
14, Botany-road	April 9.
Bourke-street (Zetland)	April 21.
Gray's stables, Elizabeth-street	April 26.

113. Lastly, on 8th June, which, as it afterwards turned out, was the day on which the last case of this epidemic was attacked, and on this part of the area, the latter was ordered to be specially searched by the rat-staff. During four or five weeks a large number of rats were gathered from 84 premises very evenly distributed over it (see diagram IV; the part referred to is bounded on two sides by Botany-road and Phillip-street, and on the third, in part, by Bourke-street). None were infected with plague.

SURVEY OF THE GENERAL RESULTS OF THE SEARCH FOR RATS OVER THE WHOLE OF THE AFFECTED AREA DOWN TO 17TH FEBRUARY.

114. In order to complete this description of the beginnings of the epidemic, it is necessary to add a reference to the general rat-search which was simultaneously carried on over a very considerable section of the city. I take, for the illustrative purpose in view, that part of it which lay between the dates, 16th November and 17th February (Case 23).

During the three months, 16th November to 17th February, rats were brought in by three agencies—the Departmental rat-staff, which delivered a few more than 12,000; the staff of the Local Authority for the city, which brought in 1,732; and those collected by the public and paid for by the Department at 3d. a head, which numbered nearly 18,000. The Departmental staff worked over a very wide area, including the city and adjacent suburbs, as well as some rather more remote which were occasionally visited, and those from which plague-cases had been removed; the city staff confined itself within its municipal boundaries, of course; while the origin of those presented by the public was seldom accurately known, though steps were taken to prevent them from being imported from distant places The Departmental staff visited and attempted to catch rats at a very large number of premises altogether, although even this total number bore but a small proportion to the total houses standing in the adjoining and other municipalities within which they worked; but the premises to which they paid *successful* visits numbered but 438 houses, &c., and 48 wharves; and their *successful* visits to this small number of premises were but 1,581. The only plague-rats which were identified were handed in by the Departmental staff; and as a rule the addresses at which rats brought in had been caught were known with certainty only when they had been taken by that staff. The net result of this hunt as regards plague rats is given below:—

TABLE XIV.—Showing the places at which identified plague-rats were collected between 16th November and 17th February, the dates on which they were collected, and the area on which these premises stood (see Diagram II).

Exton's produce store, Hay-street	November 15	South-central.
Howard Smith & Co.'s, Brisbane Wharf... ...	November 18	Darling Harbour.
Jones' produce store, 84, George-street	November 25	Chippendale.
Cleveland and Abercrombie Streets	November 26	Chippendale.
400, Kent-street, City	January 28	Darling Harbour.
Her Majesty's Hotel, 186, Pitt-street..... ...	January 29	Central.
445, Kent-street	February 6	Darling Harbour.
392, Kent-street	February 8	Darling Harbour.
169, George-street West	February 10	Chippendale.
180, Pitt street	February 14	Central.
Buchanan's, New South Head Road	February 14	Paddington.
Matheson's produce store, New South Head Road	February 14	Paddington.
10, Maclean street, New South Head Road ...	February 14	Paddington.

But these plague-rats must not be regarded as the total yielded by the 12,000 rats taken by the Departmental staff; they should be compared with the number selected for delivery at the laboratory under conditions which have been already mentioned (see par. 81); and that was 914.

115. Thus the number of places at which plague-rats were found during the three months, 16th November to 17th February, was but 13, and the number of plague-rats identified was but 18. There were, however, a large number of rats which died of plague, their carcases having been found on premises which yielded at least one identified plague-rat; and were these reckoned the proportion of plague-rats to rats caught would be very largely increased. But this would add nothing to our knowledge; for we are aware that plague often rages on premises which are grossly infested, and consequently that the number of plague-rats found must

must largely depend on the numbers which happen to lodge on the premises invaded. The more important point is to ascertain the number of separate premises and the number of different neighbourhoods in which plague-rats were found; this it is which indicates the extent to which the disease is disseminated as an epizoötic, and which, in my opinion should be compared with occurrences of it in man. That number was 13 premises only. It should surely have been larger; for some infected rats were found at several widely separated spots, and from experience at several premises (Exton's, Jones's, Huxley's) it is plain that the disease is sometimes easily communicated from rat to rat. The failure to discover more must have lain in part, then, in the mode of search; and good reason can be shown for ascribing it to this cause. The rat-staff worked at night, and with traps. They therefore caught rats which were running about and which were, for the most part at all events, in good health. Experience at Sydney has been that rats which have been attacked with plague have rarely been seen in the open; one instance has been mentioned in connection with the Paddington area, another will be mentioned in connection with a flour-mill on Darling Harbour area, another at the Zoological Garden (par. 174); but only four altogether were noted. Had they more frequently behaved, however, as they have been said to do in other countries, it is still improbable that they would have been taken in traps; for it is not likely that a sick rat would have either the energy or the inclinations which would lead it into them.

116. It seems sufficiently clear that the epizoötic did not spread very rapidly from building to building; doubtless it was often impeded by the mode of construction, which was that usual in European cities. Further, the disease seems to have been very easily communicable from rat to rat only under the special circumstance of association of large numbers in confined quarters. Nevertheless, there must have been many more infected rats than were found. Where were they, then? They must have been underground in their burrows; to them they must have retired on falling ill, and there for the most part they must have died. Some direct evidence that this does happen was yielded by the case of the Zoological Garden (par. 176); and, indeed, it was not until after that experience that the great importance to the epidemiological study of searching for and digging out burrows in connection with buildings was perceived.

117. But there was still another reason why plague-rats were not found in greater numbers; it arose from the search-conditions. In the first place, although it is impossible to estimate the number of houses on the irregular area which was the field of the operations under review with any approach to accuracy, it is quite certain that the premises at which rats were taken during the three months formed but a very small proportion of them. In the second place, it was indispensable that some number of rats should be fixed upon as sufficient evidence that each rat-catcher employed had done a satisfactory amount of work, and an effect of this practically unavoidable rule was, no doubt, to lead to payment of repeated visits to premises which were badly infested, while what was more desirable was examination of the largest possible number of different premises.

118. I conclude, then, first, that the identification of plague-rats as carried out furnished a trustworthy indication of the area of country over which the epizoötic extended, and that there is no good reason for supposing that it may have reached much beyond it; secondly, that it furnished little indication of its intensity.

119. There are two additional points upon which some remark should be made for the reader's assistance. The first is that there must, of course, have been some local *fons et origo* of the infection; and it is apparent that the latter spread from it, not by continuity at first, but *per saltum*, primary cases having been recognised in four separate districts, namely:—Cases 1 on the South-central, 10 and 12 on the adjacent Chippendale, 3 on the Paddington, and 11 on the Alexandria area. This view (of spread, at first *per saltum*, but afterwards by continuity from each new centre) depends on the cases mentioned having been primary cases in fact. Now notification of Case 1 was delayed until ten days after the date of attack; and two undiagnosed cases occurred on the Paddington area, where also Case 3 lay without medical attendance for nine or ten days after attack. These facts raise a legitimate doubt whether apparently primary cases were so in truth. Against

it may be pointed out (*a*) the absence of all ground for suspecting wilful concealment—a statement which applies as much to the Chinese, who here live as civilised and law-abiding citizens, as to whites; (*b*) that attention was drawn to one of the two undiagnosed cases by the medical man who had been in attendance upon it (to the extent, it will be remembered, of one visit paid an hour or two before death) as soon as he heard of the surrounding circumstances, while the diagnosis of the other (made after death without assistance of a detailed *post-mortem* examination) may, after all, possibly have been correct; (*c*) that all those who are best acquainted with the general circumstances do accept these early cases as having been the primary occurrences they appeared to be. Such investigations as the present would become impossible were this doubt (which, in a measure, might be raised in relation to the source of infection of every case) entertained without very good evidence for it; and evidence of the requisite kind may, in my opinion, be taken to be wanting.

120. The second point is, the detection of plague-rats (to speak generally) on premises where there was no plague in man, and the failure to find them (in a majority of cases) where there was plague in man. Enough has already been said, I think, to show that the negative aspect of these facts must be cautiously regarded. Coincidence of plague in man and in rats was demonstrated in several instances; and the failure to find plague-rats is, for substantial reasons which have been mentioned above, not even presumptive proof that plague-rats were not present. Besides this, however, it must be pointed out once more that plague-rats by themselves, and unaided, are incapable of causing epidemic bubonic plague. All that is required at this stage of the enquiry, therefore, is to show that the connection between rats and man, or the connection reasonably presumed in cases where the demonstration failed, existed as a mere matter of propinquity sufficiently often to warrant the inference that it is an essential condition of the occurrence of plague in man. This, I think, has been done even already; but much more evidence to the same purpose will be given later. However, the reader has the facts before him, and will judge of this for himself.

Darling Harbour Area.

121. The slow and obscure beginnings of the epidemic on a close-built city area, and its complete course within two other areas which comprised much more open space around the houses and much more unbuilt land in their neighbourhood, having been described, it is now necessary to give examples of its complete course, and of its relationship to epizoötic plague on areas which were altogether covered with houses, factories, markets, and wharfs. For this purpose I choose the Darling Harbour area and the Central area.

122. The number of cases which occurred upon the Darling Harbour area (see Diagram II) was 10, and they happened between 14th February and 20th April. It can be noted at once that, densely populated during the day as this area was, it did not yield cases of plague in proportionate number, although the infection was proved to have been present upon it from (I think it may be said) before the beginning of the epidemic until a date subsequent to attack of the last case by a few days, but subsequent to that of the last case on this area by nearly two months. This remark applies equally to the Central area, which yielded 32 cases between 14th February and 4th May. Yet the rise in the weekly number of notified cases which occurred, as has been shown, between the seventh and twelfth weeks (see Table II) was due entirely to addition of the 42 cases which arose on these two areas, without which the weekly number referred to would have varied between 1 and 8 only throughout the epidemic. This way of regarding the cases on the Darling Harbour and on the Central areas requires some explanation. It is justified by the fact that while the total 42 cases occurred on 29 premises, the patients resided on those premises only in 12 instances; and in the remaining 30 instances lived in districts which were for the most part remote, and, with three or four exceptions, free even from suspicion of infection with plague.

123.

123. The 10 cases grouped on the Darling Harbour area can be further divided by locality into three sub-groups. These are shown in the Table below :—

TABLE XV.—Showing the serial number, date of attack, adjudged place of infection, and place of residence of the ten cases of plague which occurred on Darling Harbour area.

Case No.	Date of Attack.	Adjudged Place of Infection.	Residence.
		A.	
23	February 14	232 Sussex-street (flour-mill)	Hugo-street, Redfern.
25	„ 18	39 Sussex-street	Lindfield.
28	„ 22	224–6 Sussex-street (produce)	Victoria-street, North Sydney.
42	„ 27	49–51 Sussex-street (produce-carter)	Young-street, Redfern.
56	March 10	125 Sussex-street (produce)	Trafalgar-street, Annandale.
72	„ 17	Barque "Eulomene"; potatoes supplied from 61–3 Sussex-street.	
		B.	
59	March 4	Barker-lane	7 Barker-lane.
89	„ 22	Miller's Wharf, Liverpool and Bathurst streets	Victoria-street.
106	April 20	Jones' Wharf (wood, coal), 2 Bathurst-street	2 Bathurst-street.
		C.	
104	April 20	Grafton Bond	74 Princes-street.

124. First of all, it must be pointed out that Cases 23, 25, 28, 42, 56, 89, and 104 resided in neighbourhoods which never yielded indigenous cases. Their home premises also were either not infested with rats or, if in two or three instances visited by rats, were so in quite a moderate degree; and no evidence of rat mortality on or in the neighbourhood of them was revealed by the inquiries which were made. Cases 59 and 106 were judged to have been infected where they lived. Case 72 was infected on board his ship, which had the communication with Sussex-street already described elsewhere (see par. 71).

125. What were the rat relations of the premises on which these cases are adjudged to have received their infection? They are shown in the Table below. It should be noted that street numbers almost always run odd and even on opposite sides of the way :—

TABLE XVI.—Showing the situation of 21 premises on the Darling Harbour area at which plague-rats were taken, and the dates on which they were taken.

Howard Smith & Co.'s Brisbane Wharf	18 November.
400 Kent-street	28 January.
445 Kent-street	6 February.
392 Kent-street	8 February.
41 Sussex-street	18 and 19 February.
31 Sussex-street	21 February.
392 Kent-street	21 February.
North Coast Co.'s Wharf	25 February.
Napoleon-street (off 6, Sussex-street and Grafton Wharf)	25 February.
Huddart, Parker, & Co.'s Wharf (about 1 Sussex-street)	28 February.
Steam Mill street (off Barker-street)	19 March.
Barker-street	18 March.
Market Wharf (near 171 Sussex-street)	14 April.
Byrnes' Wharf (foot of Liverpool-street, 345 Sussex-street)	18 April.
Federal Wharf (bond, 1st floor, 209 Sussex-street)	19 April.
S.M.C. Wharf (off 279 Sussex-street)	23 April.
89 Liverpool-street	28 April.
311 Sussex-street	1 May.
318 Sussex-street	5 May.
Duncan-street (off 31 Bathurst-street)	9 May.
Market Wharf (near 171 Sussex-street)	13 June.

126. Thus the first plague-rat of all was found at a wharf which stood more or less at the centre of the line of wharves which bounds the Darling Harbour area to the east on 18th November; the next 3 in Kent-street towards its south end, one

one block east of Sussex-street, from 26th January to 8th February; and then follows a long list of 17, taken on premises which, with two exceptions, were either actually in Sussex-street or in side streets within a few doors of it, between 18th February and 13th June (see Diagram II). Now if Table XV be compared, it will be found that the takings of plague-rats on any premises coincided in no case with occurrence of plague on those premises; and, conversely, that plague did not occur, and that cases of plague could not, in any instance, be ascribed to infection received on premises where plague-rats were taken. It may be pointed out at once that this has been our usual experience. The total number of inhabited premises, or, more exactly, of premises which harboured people during the day, but were not used as dwellings by all of them, on which plague-rats were taken, was 40 during the whole epidemic, while plague occurred on 4 of them only. But this nett statement is not all that can be said on this point. Rats which had died from some unusual cause were often found on premises where plague in man occurred. Thus, Case 23 (both sets of cervical glands enlarged, smears and cultures positive; died), occurred in a youth employed at a steam flour-mill, who said that, on the day of attack, he had killed a sick rat at the mill by stamping on it, and had afterwards picked it up and thrown it away. The date of his infection, in all probability, was earlier than that referred to, which was the day of attack; but it appears that there were sick rats, or at least the one he killed, on the premises at which he worked. Case 25 has considerable interest from the circumstances surrounding it, although it is only one of a considerable number of similar cases. The important points were as follows:—

J.B.B., m., aged 19, a railway porter employed at Lindfield station, 7 miles from Milson's Point terminus, North Sydney. He was attacked, 18th February, in the evening; he had a right femoral bubo (morphological and cultural tests, positive); recovered. He lived in the neighbourhood of Lindfield station with his father, who had stables at his detached cottage and kept horses there; on 8th February the latter had received feed from 37, Sussex-street; the cottage was in good order and repair, clean; it was said that there were some rats about it and the stables, but that none sick or dead had been found. The patient did not work for his father, though no doubt he was exposed to any risk which may have attached to the stables; but on 18th February (railway books) he had helped a consignee to unload a considerable quantity of produce from railway trucks which had been forwarded from a store at Nos. 49–51, Sussex-street. In addition to this connection of his case with these premises, he was friendly with the son of the produce dealer who occupied them; and on 16th February had gone to Sydney and had spent the morning with him. It is not clear whether or not they entered Nos. 49–51, but No. 39 was at that time vacant. It was learned that young men used to meet there, and there the patient and his friend spent an hour or two. No plague-rats were found at No. 39 (which was not visited at any time), but they were found at No. 41, next door, on 18th and 19th February.

127. Under these circumstances, it is clearly possible that this patient may have been exposed to some risk of infection from the produce bought by his father at 37 Sussex-street, and received at Lindfield on 8th February, but this remains a possibility only; he could not have received the infection from the produce he unloaded, because he was attacked on the same day. But his visit to No. 39, Sussex-street (possibly, also, to Nos. 49-51), coincided with the most probable date of his infection; for, from the morning of 16th February (say, at 11 a.m.), to the evening of 18th February (say, at 8 p.m.) is fifty-seven hours, so that his illness began during the third day after his visit. No plague-rats were found at No. 39 (they were not searched for there) but some were taken at No. 41 (next door) on 18th and 19th February.

128. Case 28 occurred in a carter at a produce store, who sometimes slept on the ground-floor premises connected with stables in the back yard; and here, when the rotten flooring-boards were removed, a mass of rat-burrows was exposed, and 6 carcases, at about the same stage of putrefaction, were removed. Case 42 occurred in a carter at Nos. 49-51, Sussex-street, just mentioned above; but there was no history of dead rats in connection with Case 56, though the patient was certainly not infected at his residence in a distant suburb, and was carter to another Sussex-street produce dealer. The premises at which Case 59 lived, though in a neighbourhood consisting of poor house property (in very bad repair), factories, and wharfs, where plague-rats had been before and were afterwards found—one of them in the lane outside his house, and close to it—offered no sign of infestation. Stables at the wharf at which Case 89 was watchman were in bad repair and order, and infested with rats, but it was said that none dead had been seen there for three months before. Case 106 was stableman at premises attached to Jones' Wharf, and slept in a species of hutch extemporised for him. It was said that no rats had been seen, alive or dead, for a long time; however, on examination,

abundant signs of present infestation were seen, and three days after this patient's attack a plague-rat was taken at the Municipal Wharf at the foot of Bathurst-street, adjoining Jones' Wharf. These premises were also infested very badly with fleas.

129. The foregoing facts afford a further and fair example of the kind of relationship between diseased rats and plague in man which we have observed on closely-inhabited and (during the day) thickly-populated business areas. The long space of time, covering duration of the epidemic, during which plague-rats were forthcoming from the area described may be noted; the small proportion of the total buildings upon it (which, together with 41 wharf premises, were 1,234) from which plague-rats were collected; the small proportion of the total number of houses in which any rats were captured (namely, 88, to which 1,170 successful visits were paid by the ratcatchers); the want of coincidence between identified plague-rats and cases of plague in man on the same premises, but also the frequent association of rats recently dead from some epizoötic disease with plague in man may be pointed out. But, on the whole, I infer that the place-connection between epizoötic and epidemic plague is far from being in reality as obscure and doubtful as from the ascertained facts, which have been given above with scrupulous precautions against exaggeration, it might be judged to be by those who have never attempted to examine the rats of a large city. For the obscurity, in my opinion, arises solely from the difficulties which the investigation necessarily presents, namely, the physical circumstances of the area to be examined and the habits of the animals, together with ineptness of the labour which alone has been available for use as an instrument of search.

Central Area.

130. We now turn to the Central area which, it seems most probable, was infected from the wharf line on Darling Harbour area, by way of streets running towards it in an easterly direction (King-street, for instance); the separation between the two areas being strongly marked by the entire freedom of Clarence-street, which runs north and south parallel with the wharf line, but some hundred yards easterly of it, both from plague-rats and from premises yielding dead rats. And it should be pointed out in relation to this latter statement (though the same is to be understood of all similar statements unless the contrary is mentioned) that the not finding of plague-rats or of dead rats in this street was not at all due to less thorough or briefer search in the houses which composed it.

131. The number of cases which occurred on the Central area was 32, and they can be divided by locality into 4 sub-groups; they are shown in the Table below.

Table XVII.—Showing the serial number, date of attack, adjudged place of infection, and place of residence of the 32 cases of plague associated with the Central area.

Serial Number.	Date of Attack.	Adjudged Place of Attack.	Residence.
A—			
18	Feb. 14 ...	Her Majesty's Theatre, 186 Pitt-street...	130 Reservoir-street.
19	Feb. 14 ...	Do do ...	22 Bullanaming-street, Redfern.
20	Feb. 15 ...	Do do ...	247 Church-street, Camperdown.
21	Feb. 12 ...	Do do ...	115 Nelson-street, Leichhardt.
33	Feb. 25 ...	Her Majesty's Hotel, do ...	Her Majesty's Hotel, 186–8 Pitt-st.
22	Feb. 16 ...	George Hotel, 188 Pitt street	George Hotel, 188 Pitt-street.
34	Feb. 24 ...	Siddaway's, 47 Market-street	59 High Holborn street.
43	Feb. 27 ...	Do do	Bondi.
B—			
26	Feb. 19 ...	Criterion Hotel, 258–262 Pitt street ...	George-street, Redfern.
27	Feb. 22 ...	Do do ...	Paragon Hotel, Circular Quay.
29	Feb. 21 ...	Do do ...	Criterion Hotel, 258–262 Pitt-street.
31	Feb. 23 ...	Do do ...	do do
32	Feb. 22 ...	Do do ...	do do
39	Feb. 24 ...	Do do ...	do do
40	Feb. 25 ...	Do do ...	do do

Serial Number.	Date of Attack.	Adjudged Place of Attack.	Residence.
C—			
41	Feb. 27 ...	482 George-street (chambers)	Orwell-street, Pott's Point.
51	March 3 ...	(?) 251–7 Pitt-street	198 Oxford-street.
46	March 3 ...	(?) G.P.O., 137–57 Pitt-street	Hurstville.
49	Feb. 28 ...	237 Pitt-street	Petersham.
55	March 12 ...	155 King-street...	164 Woolloomooloo-street.
57	March 10 ...	Imperial Arcade (off 170 Pitt-street) ...	165 Liverpool-street.
76	March 16 ...	105 King-street...	Bannister-lane, Ultimo.
80	March 25 ...	134 King-street...	134 King-street.
81	March 25 ...	Strand Arcade (off 195 Pitt-street) ...	Randwick.
84	March 26 ...	Royal Arcade, 267 Pitt-street	Strathfield.
116	May 4 ...	(?) 305 Pitt-street	37 Hutchinson-street, Surry Hills.
D—			
52	March 11 ...	Central Exchange Coffee Palace ...	Central Exchange Coffee Palace.
53	March 11 ...	Do	do
60	March 13 ...	(?) Do	115 Erskineville-road.
67	March 18 ...	111 York-street...	70 Walker-street, Redfern.
69	March 13 ...	(?) Central Exchange Coffee Palace ...	554 Crown-street.
75	March 20 ...	35 Market-street	8 Healey-street.

132. The 32 cases which occurred on the Central area were infected, as far as can be judged, on 17 premises only. A note of interrogation preceding the adjudged place of infection intimates that doubt attaches to it in that relation. At Her Majesty's Theatre and Hotel (which constituted one building structurally) 5 cases occurred, 2 at Siddaway's boot factory, 47 Market-street, 7 at the Criterion Hotel (and Theatre), 2 (probably) at chambers which ran through from 251–7 Pitt-street to 482 George-street; and in the Group D, which lay west of George-street, 4 (probably) in connection with the Central Exchange Coffee Palace. Their dates of infection extended only between 14th February and 26th March, if Case 116 (attacked 4th May) be omitted which may perhaps be done, because there was almost equally strong reason against regarding either the patient's place of residence or his place of employment as the place of his infection.

133. The ascertained state of the Central area as regards epizoötic plague is shown in the table below:—

Table XVIII.—Showing the situation of premises on the Central area at which plague-rats were taken, and the dates on which they were taken.

Her Majesty's Hotel and Theatre, 186–8 Pitt-street ...	Jan. 29, 30, 31, Feb. 1, 8, and 11.
180 Pitt-street	Feb. 14.
484A George-street...	Feb. 22.
Imperial Arcade, next 170 Pitt-street	Feb. 25.
74–78 King-street	Feb. 25.
King-street (F.F.I. Co.'s "new shop")	Feb. 26.
St. Andrew's School, 314 Pitt-street	March 4.
92 King-street	April 4, 5.
218 Pitt-street	April 5, 11.

134. On this area, then, plague-rats were identified in connection with Her Majesty's Theatre and Hotel (but see the special account of these and other premises which yielded multiple cases, pp. 52–56); dead rats in number at the Criterion Hotel; the same at 47 Market-street; a plague-rat at 484A George-street on 22nd February, which building is next to 482, where on 27th February Case 41 was attacked, and which also ran through to 251–7 Pitt-street, where Case 51 (attacked March 3) was at work as a house painter. Case 49 worked at a very badly infested tailor's shop, though no carcases were found at it. Case 55 worked at an hotel, where plenty of rats had been seen, and where (as the patient said) a sick rat had been caught the day before his attack, though no carcases were found. It was ascertained at the restaurant at which Case 57 worked, that 3 dead rats had been taken from under a staircase a few days before her attack, and it will be observed that No. 170 Pitt-street (see Table XVII) is but five doors from No. 180, where a plague-rat was taken on 14th February. Case 76 worked at a mercer's, which was badly infested, and whence 4 putrid carcases had been removed three days before her attack,

and

and 4 rat-nests from under the flooring-boards. Case 80 lived at a publichouse very badly infested, both by vermin and rats, whence 4 carcases and large quantities of rubbish accumulated by rats were removed. Case 84 occurred at a tailor's, where 9 carcases were removed from under the floor of the room in which the patient had worked, as well as very large quantities of accumulated rat-rubbish. So, also, as regards Sub-group D, very many carcases, live rats, rats' nests, and large accumulations of rat-rubbish were removed from the place at which Cases 52 and 53 lived and were attacked (compare, also, Cases 60 and 69, who more or less regularly frequented this eating-place). But, as regards the rest of this sub-group, no good evidence of disease among the rats which, nevertheless, infested the places of their employment, was obtained. Next, as regards the dwellings of those who did not reside at the adjudged place of their infection (namely, 22), seven lived in very remote suburbs, at distances of from 3 miles to 9 or 10 miles, only one of which ever yielded an indigenous case (but see Cases 61 and 127, Camperdown area, for the special circumstances), or harboured an imported case. The remainder lived at less distances of a mile or two, and not in suburbs; a majority of them dwelt in neighbourhoods which never fell under suspicion of infection. There were but two or three among them who could be considered to have run some danger from locality, but in no case were the dwellings of any of them found to have harboured dead rats, or to be infested with rats; nearly all of them having been absolutely free from all traces, I will not say of infestation, but even of visitation. Enough has been said, perhaps, of the Central area to show once more the kind of relationship which has been observed between plague-rats, or dead rats, and plague in man; and to show why, in the absence of evidence of spread by all those means which are elsewhere constantly invoked to explain the epidemicity of plague, we have concluded that, at Sydney, epizoötic plague is causally connected with epidemic plague, and not merely with occasional individual cases of this disease.

General Survey of the Remaining Areas.

135. The North-central area afforded but 6 cases of plague, of which 5 occurred at one house. Further reference to it may, therefore, be delayed until premises which yielded multiple cases come to be separately examined; but in the meantime it should be noted that in all respects of occupation and population, it was similar to the Central area just dealt with. Two of the 5 areas which alone remain to be noticed yielded 6 cases each on 5 premises in each, while the other 3 yielded only 2 cases each on 2 premises in each. These 5 areas are Woolloomooloo, South-west central, South-east central, Pyrmont, and Camperdown. Plague-rats were found in some neighbourhood or other at some date or other on each of them; but it is hardly worth while to continue the illustrations already given in detail of the kind of connection which existed between them and occurrences of plague in man, since the result would merely be to further exemplify what has already been described at length. Yet there is one which presented noteworthy points, of which, therefore, some details may be usefully given.

Camperdown Area.

136. Case 20, occurred in a scene-shifter, employed at Her Majesty's Theatre, who was adjudged to have been infected there, and who was attacked at home during the night of 15th February; he lived at 247, Church-street, Camperdown, and he lay there until 17th February, or for about 40 hours, when he was removed to hospital. He had a right inguinal bubo, morphological test positive; recovered; duration of illness, 23 days. Disinfection of his small one-storey cottage was begun immediately after his removal, and was quickly completed. It was of wood and brick, dilapidated, dirty, damp, rotten, and infested with insects, but free from all traces of rats.

137. A month later—that is to say, on 13th March—Case 61 was attacked at 77, George-street, Camperdown, 7 or 8 chains easterly from Case 20 (see Diagram II). This patient was an old woman, who had not been away from home for a long time past. She had a right axillary bubo, was removed on the third day of illness, and died on the fifth day. Her cottage was of brick and weatherboard, and in a condition which

which rendered it unfit for habitation, so that soon afterwards it was pulled down with consent of the owner. It was very badly infested with rats; the patient's husband said he had removed 3 carcases from his bedroom on 6th March, but also that he had previously laid poison; on raising the floors abundant traces of present infestation were found, and 3 more putrid carcases were removed from under the bedroom floor. On one side of this cottage was a house which had a stable attached to it.

138. In consequence of occurrence of Case 61 a block which was bounded by George-street, Church-street, Burton-street, and Missenden-road was taken in hand by the cleansing staff on 25th March (finished 7th April), which included a produce store at the corner of Missenden-road and George-street. Prior to this the neighbourhood had begun to be searched by the rat staff, but nothing of importance had resulted, except that rats were found in considerable numbers at the produce store just referred to—17 having been caught there by it on the night of 25th March.

139. After a rather long interval, namely, on 21st April, one plague-rat, and on 23rd April, 3 plague-rats, were brought in from the store (search of these particular premises having been intermitted of course, and probably resumed merely because it was a good place at which to catch rats), whereupon the place was closed for cleansing and reconstruction. It included no living apartments; its proprietor occupied a house erected on a low bank at the back of it, entirely detached, and reached by a flight of uncovered wooden steps. Here his wife (Case 127) was attacked with plague on 13th May; she exhibited a right axillary bubo, and recovered. No further carcases were found at the dwelling, which was reported to have been in good order and repair; the store had continued closed from about 25th April, cementing of rubble foundation-walls and concreting of the floor not having been completed until long after attack of Case 127.

140. This instance presents several points which deserve attention. In the first place the neighbourhood was remote from other infected spots, and doubtless received its infection *per saltum*; in that case there is a reasonable presumption, raised by experience on other remote areas already recounted, that it was transported there with supplies delivered at the produce store. Now the owner of the stable next to the house at which Case 61 lay procured his feed from this store. But the dates do not nearly agree. Case 61 was attacked 38 days before a plague rat was found at the produce store, and as far as this point furnishes a hint it suggests that the infection was really travelling the other way—that is to say, easterly from Case 61 towards the produce store, and not westerly from the store to Case 61.

141. Attention is thus drawn to Case 20, which lay still further west of the produce store than Case 61, and to the statement which has been made that the infection is commonly introduced to a clean neighbourhood by man and communicated from him to the rats.* Evidently, from the pathology of plague, this might happen, although reason has never appeared in our experience for suspecting it; and the present instance seems to me not to be one which suggests that sequence of events. For, on those same pathological grounds, a case of bubonic plague of an unusually mild description (the patient was discharged from hospital on the twenty-third day of illness) cannot be supposed capable of diffusing infectious matters during the first 40 hours after the onset, within which term this patient was removed to hospital; his cottage, it will be remembered, having been disinfected immediately afterwards, and finished within less than 72 hours of his first symptoms. There is thus every reason for regarding Case 20 as independent altogether of the two subsequent cases and of the plague-rats afterwards found, and as having been merely one of those imported cases of which so many were met with during the former (as well as during this) epidemic, and from which no communication of the disease either from man to rats or from man to man ever took place.

142. How did Case 61 come to be infected from the produce store since plague-rats were not found at it until 38 days later? There is, indeed, no more than a suggestion that the infection was received thence; and the possibility must be

* See for instance Memorandum on the Influence of Rats in the dissemination of Plague, by W. J. Simpson, M.D., printed for use of the Colonial Office, May, 1900. "Man as a rule is the chief importer of plague into a locality, while the rat at the commencement is the chief disseminator."

be noted that it was carried into the neighbourhood in some quite other and undiscovered way, and that it may have spread gradually from some point much further to the west, perhaps, than even Case 20, through the premises at which Case 61 dwelt, and so towards the produce store. Such conjectures, however, are merely disabling unless they arise in some ascertained probability; and no such probability ever appeared, notwithstanding such a watchful examination and consideration of the circumstances as at the time justified the setting aside of the origin of the infection which the certainly indigenous Case 61 had received as an unsolved problem.

143. We have then to review the data, and on doing so it appears that as a matter of fact there is no evidence that the produce store was free from rat-plague at any particular date prior to 21st April. Even the healthiness of the 17 rats taken there on 28th March must remain doubtful, for at that date only selected rats, and those chosen by the rat-catchers themselves in accordance with rough general rules which have already been mentioned, were delivered at the laboratory; while, as noted above, the premises were not kept under anything approaching continuous observation after failure of the efforts to discover plague-rats in the neighbourhood, which were made immediately on notification of Case 61. Hence this case illustrates the practical difficulties met with in attempting to demonstrate in the field the nature, in particular instances, of the connection between epizoötic and epidemic plague, as much as anything else; and therefore it may be left, after it has been pointed out that Case 127 did not occur in the detached, elevated, cottage behind the produce store, until the latter had begun to be thoroughly turned out in the course of repairing it so as to render access of rats to it less likely, and the burrowing of rats under its floors and about its foundations almost impossible.

Description of a Single Indigenous Case at Newtown.

144. There is also one case, solitary and detached by neighbourhood from all others, which occurred at Newtown; it deserves description, because the discovery of plague-rats once more clearly preceded the infection of man by several days.

145. On 23rd April the Sanitary Inspector to the Local Authority for Newtown delivered at the laboratory two rats which had been picked up in a lane at rear of premises occupied by the Davis Butchering Co., 257, King-street; they presented gross signs like plague, but were too putrid for demonstration of the nature of their disease. On each of the days, 25th, 26th, and 30th April and 1st May, other rats caught or found dead on the premises named were brought in by the Departmental staff to the number of 62, ten of which were ascertained to be infected with plague. No plague-rats were collected from adjoining or adjacent premises; and as soon as the butcher's shop had been closed and handed over to the cleansing-staff, together with the whole block in which it stood, delivery of rats at the laboratory ceased, in accordance with the custom which arose merely in the exigencies of work, and which was designed to relieve the laboratory staff as soon as the fact that the rats on any particular premises or in any cleansing-block of buildings were infected with plague had been firmly established. The shop was of moderate size, in a city street; it was in very bad structural state, and had a small yard entirely built over. The latter contained stables where several horses were kept, annexes used for purposes of the extensive business, and accommodation for the slaughtering of fowls which were temporarily housed there to an average number of about 2,000.

146. There were also in the same block several old premises which had been allowed to stand from times when this suburb was rural until leases should fall in; they were in an indescribable state of disrepair, though presenting to the high road on which they stood shop-fronts which, to the casual observer, were not quite disreputable. All of these were so badly infested with rats and clogged with rats'-dung in every part not habitually walked over that it seemed doubtful whether man or the rats might more justly be deemed to have possession. These shanties were interspersed among many fine buildings which from time to time had been erected on allotments of which the leases had fallen in more or fewer years before; and

their

their continued existence was a disgrace to the Local Authority, who appeared to be ignorant of the ample powers which they possessed under the Public Health Act, 1896, to cause them to be closed and demolished.

Case 108. A. P., m., 54; suddenly attacked 27th April; left femoral bubo; recovered. Was a cabinetmaker employed at 363 Kent-street, with eight others; the shop was in excellent state, and no suspicion ever attached to it. Resided at 245 King street, Newtown, five doors from the Davis Butchering Company, and in the block which was cleansed in connection therewith. Here his family kept a stationer's shop; the building was in bad repair, average cleanliness, and on being taken in hand by the disinfecting staff was found to show abundant signs of being badly infested with rats; but only one carcase was removed from beneath one of the floors.

147. The carcases brought in on 25th April had been soon ascertained with sufficient completeness, under the circumstances, to have died of plague; but time was afterwards lost in attempting to get the Local Authority to do its duty, under supervision, without success; and partly in consequence Case 108 was attacked before cleansing of his premises had begun.

148. Here we see an instance of place infection *per saltum*, and a further instance of precedence of rat-infection over the infection of man. Here, also, is another illustration of our not uncommon experience—namely, that persons exposed on premises where rats are most numerous and are suffering most heavily from plague are, nevertheless, not necessarily the first to suffer, nor even sure to be attacked at all; while persons living in the neighbourhood on premises which show no important sign of presence of epizoötic plague may and do suffer. In short, as we know that plague-rats are not in and by themselves infective for man, so we are compelled by this and many similar examples to assume that the chain of circumstances necessary to bring about communication of this septicæmia of the rat to man is lengthy, and rarely complete in all its links; for though the neighbourhood of plague-rats seems necessary to bring about infection, contact with them is clearly not necessary and, if brought about, does not ensure, nor much increase the probability of, its being contracted.

149. With the two preceding instances, which present features differentiating them from others so far mentioned and worthy of careful consideration, I conclude this exposition of the beginnings of the epidemic, to which accounts of its complete course on certain areas have been added. It does not comprise a reference to every case that occurred, nor a description of the events recorded of every area; but it has been carried almost as far as is necessary to pourtray the usual course of events, and (it is hoped) to place the reader in possession of the general grounds on which we have formed our opinion that epizoötic plague among rats is here a precedent and indispensable condition of epidemic plague. It remains, however, to examine the distribution of cases among houses in relation to alleged spread of the infection of plague from the sick to the well by direct, and by indirect, channels. Before doing so, however, there still remain two occurrences which must not be omitted from description. One concerns plague in man, marsupial and some other animals, and in rats at the Zoological Garden at Sydney; the other a solitary indigenous case at the city of Newcastle. Both of them throw light on the practical management of plague-epidemics; the former also contains some novel observations of interest.

Plague at the Zoological Garden.

150. On 11th April, the Superintendent of the Zoological Garden submitted the intestines and liver of a wallaby for examination in the analytical laboratory. He said that during the preceding six days 7 kangaroos and wallabies, which had been in apparent good health, had suddenly fallen down, become convulsed, and had died after about two hours' illness, whence he suspected poisoning. In the analytical laboratory signs of disease were noticed in the liver, and the specimen was referred to the micro-biological laboratory. By the 18th April it had been definitely ascertained that this animal had died of plague.

151. On that date, therefore, the Secretary to the Trustees was directed to close the Garden to the public, and he was informed that a thorough cleansing and disinfection of the grounds and cages must be commenced at once. The work was carried out under immediate direction of Sanitary Inspectors of this Department, the Trustees having found labour and materials. 152.

152. Before proceeding to describe the course of events subsequent to 18th April, it will be well to mention the organisation which existed, as well as the state of the Garden, at the time it began to be cleansed. The Garden was first established in 1880. It was placed under management of a Board of Trustees. Its income was made up of donations, subscriptions, admission moneys, and a small annual subsidy from public funds, and had never been quite adequate to the reasonable needs of the institution. These facts are mentioned because, although the collection of specimens, the laying out of the Garden, the arrangement of cages and enclosures, and the general appearance of the institution were highly creditable to the Trustees, many and serious defects came to light, of which some could not have been effectually prevented or removed, except at a cost far beyond any resources which ever had been at their command. The Board has now drawn attention to this matter, and has submitted several recommendations upon it to the Government.

153. The Garden occupied a triangular piece of land which measured about twelve acres and a half, and which was enclosed by a galvanized iron fence in bad repair; it occupied the angle formed by the junction of Cleveland-street with Randwick-road, and was bounded towards the north by Moore Park, towards the east by a great extent of park lands, while on its third side there were no houses towards the west for a hundred yards (see Diagram II). The subsoil was blown sand, of great depth. Water was supplied from the public mains; but in the middle of the well-planted enclosure was a small lake, which was filled by surface-waters. The lake was furnished with an overflow pipe, which entered a sluice-box on its bank; the drain from the sluice-box was of 6-inch e.w.g. piping, the mouth of which was defended by a wooden sluice-valve, found on examination to effectually stop it, and said not to have been raised since heavy rain had fallen several months before; it discharged into a covered storm-water drain 30 or 40 chains distant. At beginning of April the pond was already almost dry.

154. About the date at which the unusual mortality among the caged animals began, the collection consisted of between 400 and 500 specimens. The staff comprised 6 keepers, 3 gardeners, a butcher, a gate-keeper, and a carpenter, under a working superintendent (Mr. Holmes). The cages were for the most part arranged around the three boundaries, but not everywhere in single lines; there were, in addition, many aviaries and houses scattered about the inner part of the grounds. There were also a refreshment room, a pavilion for visitors, an office building, and a residence for the superintendent, who was the only member of the staff who slept on the premises. Near one corner of the triangular enclosure was a slaughter-house and boiling-vats; here, also, was a dung-heap, where it had been the custom to accumulate all stable-bedding and refuse for twelve months at a time, with a view to using it at the proper season to enrich the sandy soil.

155. The premises were not connected with the sewers. The public urinals discharged into the sand; other conveniences were furnished with pails, which were emptied by the staff, the contents being utilised about the grounds. Several of the cages occupied by the larger animals drained by e.w.g. piping to the little central lake; but others of them had wooden floors, through which stalings and the like found a way to the under-space, which in some cases was enclosed by brick walls, and was dark and filthy. The enormous dung-heap, then representing about eleven months accumulations, was offensive; and at this part of the grounds were several cottages, or small wooden buildings, which at some time had been in use, but which had become ruinous, filthy, and overgrown with weeds. Near by was the slaughter-yard, which was unsuitably found; although superficially not very unclean, it was in reality extremely foul, and its construction was such that it hardly could have been kept strictly clean. A very large quantity of lumber and refuse was removed from various parts of the enclosure, and burned; and some places were so offensive that the men could work for only a few minutes at a time. In short, it seemed remarkable, under these conditions, that none of those outbreaks of septicæmic diseases, to which animals in confinement are especially subject, had previously been reported.

156. The cleansing operations occupied several weeks, and during the earlier part of them the mortality among the caged animals continued unusually high. Whereas the monthly number of deaths was said to have been generally from 5 to 8, between

between 5th April and 10th June no less than 52 occurred. The bodies of 15 of these animals were examined in the laboratory, with the results described by the Micro-Biologist in the following report. Briefly, in 11 carcases, which comprised 7 marsupials, 1 Indian antelope, and 3 guinea-pigs, plague was demonstrated; in 8 carcases, which included 6 marsupials, although the *post-mortem* signs suggested death from plague, bacteriological tests did not confirm the suspicion; while in the remaining 26 no signs of plague were discovered, 4 of the carcases having been received in too putrid a state, while 10 others furnished clear evidence of some other cause of death.

Bacteriological Report on an outbreak of Plague amongst Animals at the Zoological Garden. By Frank Tidswell, M.B., M.Ch., D.P.H., Micro-Biologist to the Board of Health.

157. It has happened that from time to time the viscera of various animals dying under suspicious circumstances at the Zoological Gardens have been submitted to this Department for chemical analysis. In accordance with this custom the stomach and liver of a Wallaby (Macropus sp.) was brought to the chemical laboratory on April 12th, 1902, but was referred to this laboratory because the liver showed signs of being diseased. On examination this organ appeared to be swollen and softer than natural. It was deeply congested, and showed numerous greyish white necrotic looking areas of various sizes, but mostly about 4 or 5 millimetres in diameter. Smear preparations revealed the presence of numerous bacilli, most abundant in the necrotic areas, but present also in the tissue between them, the appearance of which suggested *bacillus pestis bubonicæ*. The further examination of these micro-organisms gave the following results:—

(*I.*) *Morphological characters.*

158. Bacilli in the original preparations polymorphic, but for the most part ovoid or shortly cylindrical with rounded ends; measuring 1·6–2·4μ long, by ·5 to ·8μ broad. Specimens from cultures were more regularly in form of bacilli and shorter than in the original preparations. Specimens from dry agar cultures showed numerous swollen, rounded or oval, often vacuolated elements (involution forms). In the original preparations and those from solid culture media the individual bacilli were isolated, but preparations from broth showed short chains. In hanging drop preparations most of the elements were quiescent; here and there some were found wriggling, but no change of place occurred. No spores were observed, neither in the original preparations nor in any from cultures or tissues subsequently examined. The bacilli stained readily with ordinary aqueous solutions of fuchsine or methylene blue, showing marked bipolar colouration, but were discolourised by Gram's method.

(*II.*) *Cultural characters.*

159. *On nutrient agar* at 36°C. inoculated with the original material, the growth was visible in about twenty-four hours in the form of minute bright dots. During the succeeding few days these became more or less fused into a confluent growth; semi-transparent at the edges, cloudy in the middle. Sub-cultures appeared in about twenty-four hours in the form of faintly cloudy streaks 2 or 3 millimetres wide, sticky. The growths were composed of bacilli possessing the morphological characters described above. *On dry agar* the growth was very scanty and showed numerous involution forms, as already mentioned. *On nutrient gelatine plates* at room temperature, growth appeared in forty-eight hours in the form of colourless dots. Under the microscope the colonies were granular, generally rounded in outline, but showing blunt angulation at different points of the circumference. *In gelatine tubes* the surface streak was whiter than upon agar, and the granular growth appeared for a short distance below the surface in stab cultures. The gelatine was not liquefied. *On Loeffler serum* at 36°C. sub-cultures appeared in twenty-four hours, and subsequently developed into a streak 2 or 3 millimetres broad, thicker than corresponding agar growths. *In bouillon* at 36°C. there was a formation of spicules of growth attached to the sides of the tubes, and a scanty deposit at the bottom; the broth remained clear. Special sub-cultures in flat flasks gave abundant stalactitic growths.

(*III.*) *Pathogenic characters.*

160. Guinea-pig A, inoculated in leg from a twenty-four hours old agar culture, became sick in twenty-four hours, developed a bubo on following day; was comatose on third day, and found dead on morning of fourth day after inoculation. The region of inoculation was swollen, and showed haemorrhagic oedema; adjacent inguino-femoral lymphatic glands swollen, deep red in colour, and surrounded by sanious effusion. Numerous small hæmorrhages under the skin and serous membranes, and in heart, lungs, liver, kidneys, spleen and intestines. Viscera showed general congestion. Liver enlarged, and showed greyish necrotic spots. Spleen enlarged and richly mottled with small grey necrotic spots. Suprarenal bodies deep red in colour. The bacilli above described were abundantly present in the blood and viscera generally, and pure cultures were obtained upon various media inoculated with material from the inguino-femoral glands, liver, and spleen.

161. Guinea-pig B, inoculated from same culture as A, became sick in twenty-four hours; bubo developed in same day; got gradually worse during next two days; was comatose on evening of fourth day, and was found dead on the morning of the fifth day after inoculation. *Post-mortem* appearances of practically same character as guineapig A, but spleen larger and even more richly mottled with greyish areas. The bacilli were abundantly present in preparations from the bubo, liver, and spleen, and were obtained in pure cultures from same organs.

162. Guinea-pig C, inoculated in the leg with scrapings from the liver of guinea-pig A, became sick and developed bubo in twenty-four hours; got gradually worse and died during the fourth day after inoculation. The *post-mortem* appearances were similar to those in guinea-pig A. The bacilli were abundantly present in preparations made from the spleen, liver, bubo, and blood, and were obtained in cultures.

163. A rat—which had been kept in a cage for about a month during which time it remained in apparently perfect health—was inoculated in the leg from an agar culture obtained from original material. The animal was slightly sick in twenty-four hours, grew gradually worse, and died on the fourth day after inoculation. The *post-mortem* examination revealed extensive hæmorrhagic œdema spreading up leg and along abdomen as far as chest. Inguino-femoral glands swollen, and deep red in colour. numerous small hæmorrhages under serous membranes, and in heart, lungs, liver, spleen, kidneys, and intestines; pneumonic consolidation of lungs; liver enlarged to nearly twice normal size, spleen swollen to three or four times normal size; suprarenal bodies swollen and deep red in colour; the peritoneum contained an excess of serous fluid. Bacilli abundantly present in preparations from bubo, peritoneal fluid, liver, and spleen, and obtained in cultures from same organs.

164. The issue of these various observations thus afforded abundant confirmation of the original impression that the micro-organisms in question were *bacillus pestis bubonicæ*.

165. From the date of receipt of the specimen just mentioned (12th April, 1902) up to 10th June, 1902, examination was made of forty-five animals dying at the Gardens. With one exception these animals were subjected to regular *post-mortem* examination, and materials then taken were used to perform a series of tests similar to those described in connection with the first specimen. The observations are briefly stated in the subjoined tabular statement. The heavy pressure of laboratory work prevented the performance of any experiments other than those required to confirm or negative plague, but obvious indications of other diseases are duly noted in the table. (Page 43.)

166. Perusal of the list there given will show that with respect to the results of the examination the animals can be divided into three classes,—

(*a*) Those positively ascertained to be infected with plague; comprising eleven animals, viz., four wallabies, one wallaroo, one pademelon, one tree kangaroo, one Indian antelope, and three guineapigs.

(*b*) Those in which the *post-mortem* signs were suggestive of plague, but the subsequent bacteriological tests were negative; comprising eight animals, viz, New Guinea kangaroo, pademelon, native cat, rabbit-bandicoot, Indian sheep, macaque monkey, and two opossums.

(*c*) Those in which both the post-mortem examination and the confirmatory tests were negative; comprising the remaining twenty-six animals. Of these four, fallow deer, axis deer, opossum, and macaque monkey, were too putrid for satisfactory examination; ten, polar bear, tiger cat, opossum, guinea pigs (2), New Guinea monitor, Syrian goat, Australian eagle, Australian owl, and magpie, showed evidence that death might have been due to other causes, whilst the remaining twelve, macaque monkey, kangaroo rat, native cat, coypu rat, guinea pig, and seven birds, adjutant, flamingo, crane, ducks (3), and marten, gave entirely negative results.

167. It will be seen, therefore, that plague was actually found to have affected seven marsupials, one ungulate and three rodents; that there was unconfirmed suspicion of it in six marsupials, one ungulate and one monkey. For the rest it need only be noted that none of the birds examined showed any signs of plague.

168. It may be added that between dates 16th April and 10th June, 1902, there were examined seventy-six rats taken at the Zoological Gardens, and of these no less than nineteen were found to be infected with plague. As stated elsewhere there was also a case in a human being in connection with this outbreak.

169. The association of plague in the lower animals with epidemics in man forms a noteworthy feature of the older writings upon the disease. Modern observation has shown that many species are susceptible to artificial infection, and that some few, notably monkeys and rodents (rats, mice, bandicoots, squirrels and marmots), acquire plague by natural means. The guinea-pig and rabbit are readily infected artificially, but I believe there is no record of a natural epizoötic amongst them. The carnivora are said to be much less susceptible; cats occasionally take the disease, but dogs appear not to do so. The Ungulata are variably, and in general only slightly, susceptible to artificial infection, and it is doubtful whether the disease is capable of becoming epizoötic amongst them. There is no reference in available records to other species of mammals. Amongst birds, pigeons and domestic poultry are said to have suffered, but the evidence with respect to their susceptibility is contradictory. The data concerning reptiles is equally uncertain; some observers assert, others deny, the susceptibility of snakes, lizards and frogs. There is no available evidence with respect to the fishes. The only records concerning the invertebrata with which I am acquainted report the death of flies, and the presence of the bacilli in, or in the excreta of, ants, fleas, and bugs. As far as I have been able to ascertain the series of cases now reported upon contain, the first recorded instances of the infection in marsupials. The special selection of these animals is interesting in view of the belief in their zoological kinship to rodents.

Table XIX.

No.	Date.	Animal.	*Post-mortem* Appearances.	Bacteriological Examination.				Diagnosis.	Remarks.
				Specimen	Smear Preparations.	Culture	Result of inoculation.		
1	1902. 12 April ...	Wallaby, *Macropus sp.*	*Vide* supra	*Vide* supra.				Plague.	
2	17 ,, ..	Fallow Deer, *Cervus dama*, Linn.	Portion of liver; no definite pathological lesions	Liver	N ...	Overgrown	...	Negative	Specimen putrid.
3	24 ,, ...	Wallaroo, *Macropus robustus*, Gould.	Bubo in left inguinal region, suppurating; no hæmorrhages; liver shows numerous small necrotic areas; spleen greatly enlarged and softened	Spleen Liver Left inguinal glands.	N ... P ... P ...	... ...	... ...	Plague.	
4	24 ,, ...	Pademelon, *Macropus thetidis*, Lesson.	Bubo of left inguinal region; hæmorrhages in inguinal and axillary regions on both sides, in liver, stomach, intestines, kidneys, suprarenal bodies, and lungs; excess of fluid (sanguineous) in peritoneal and pericardial sacs	Left inguinal glands. Liver Spleen	P ... P ... P ...	... P ... P ...	... ...	Plague.	
5	27 ,, ...	Tree Kangaroo ...	Bubo of left inguinal region; hæmorrhages in inguino-femoral, axillary, and mesenteric lymph glands, heart, lungs, liver, kidneys, suprarenal bodies, stomach, intestines, and into peritoneal membrane; bladder contains blood-stained urine; excess of sanguineous fluid in pericardial and peritoneal sacs	Left inguinal glands. Liver Spleen	P ... P ... N ...	P ... P ... P ...	... ...	Plague.	
6	28 ,, ..	Native Cat, *Dasyurus viverinus*, Shaw.	No signs of disease	None ...	...	...	...	.....	Killed in mistake for rat.
7	29 ,, ...	Kagu Crane, *Rhinochetus jubatus.*	No signs of disease	Liver Spleen	N ... N ...	N ... N ...	... ...	Negative.	
8	29 ,, ...	Kangaroo Rat, *Æpyprymnus rufescens*, Gray.	No signs of disease	Liver Spleen Left inguinal glands.	N ... N ... N ...	N ... N ... N ...	... ...	Negative.	
9	29 ,, ...	Opossum	No bubo; hæmorrhages in skin, liver, kidneys, suprarenal bodies, stomach, intestines, mesenteric glands, heart, and lungs; excess of clear fluid in peritoneal sac; liver and spleen slightly enlarged	Liver Spleen	N ... N ...	N ... N ...	... ...	Negative.	
10	29 ,, ...	Pademelon, *Macropus thetidis*, Lesson.	No bubo; hæmorrhages in skin, muscle, liver, spleen, kidney, suprarenal bodies, stomach, intestines, mesenteric glands, heart; bleeding from nasal mucous membrane; excess of clear fluid in peritoneal sac; liver and spleen slightly enlarged	Liver Spleen Nasal m.m.	N ... N ... N ...	N ... N ... N ...	... ...	Negative.	
11	29 ,, ...	New Guinea Kangaroo.	Bubo of right inguinal region; hæmorrhages in skin, peritoneal serosa, liver, spleen, kidneys, suprarenal bodies, stomach, intestines, mesenteric glands, heart, and lungs; bladder contained blood-stained urine; liver, spleen, and mesenteric glands enlarged; lungs show patchy pneumonia; nasal mucous membrane deeply congested; subcutaneous œdema in ventral parts	Liver Spleen Right inguinal glands Mesenteric glands ... Nasal m.	N ... N ... N ... N ... N ...	N ... N ... N ... N ... N ...	... ...	Negative.	
12	29 ,, ...	Adjutant Bird, *Leptoptilus argala*, Linn.	No bubo; numerous small hæmorrhages in bowel, none elsewhere; no definite changes in organs	Spleen Liver Blood	N ... N ... N ..	N ... N ... N ...	... ...	Negative.	
13	29 ,, ...	Macaque Monkey, *Macacus sp.*	No bubo; no hæmorrhages, and no definite pathological lesions	Liver Spleen	N ... N ...	N ... N ...	... ...	Negative.	
14	29 ,, ...	Polar Bear, *Ursus maritimus*, Linn.	No bubo; inguinal and axillary glands deep red on section; viscera generally congested; lungs pneumonic; animal emaciated and dirty; had been ailing several months; illness said to have started from broken tooth	Liver Spleen Right inguinal glands Left ,, ,,	N ... N ... N ... N ...	N ... N ... N ... N ...	... ...	Negative.	Viscera gave streptococcus and pyogenes and staphylococcus phyogenes aureus.
15	1 May ...	Owl (Australian Species), *Strix delicatula*, Gould.	Emaciated; no hæmorrhages; general congestion of viscera; had had diarrhœa	Liver Spleen Heart-blood	N ... N ... N ...	N ... N ... N ...	... ...	Negative.	Bacillus isolated; resembled chicken cholera, but not pathogenic to fowls.

No.	Date.	Animal.	*Post-mortem* Appearances.	Bacteriological Examination.				Diagnosis.	Remarks.
				Specimen.	Smear Preparations.	Culture.	Result of Inoculation.		
	1902.								
16	1 May ...	Indian Sheep, *Ovis sp.*	Bubo of right inguinal glands; hæmorrhages in subcutaneous tissue, under peritoneal serosa, in heart and lungs; viscera generally congested; lungs pneumonic; decomposition commenced at time of examination	Liver Spleen Right inguinal glands	N ... N ... N ...	N ... N ... N ...	... ...	Negative	Some bacilli resembling *B. Pestis* in smears, but not confirmed by other tests.
17	4 ,, ...	White Duck	No definite *post-mortem* signs	Liver Spleen Heart-blood	N ... N ... N ...	N ... N ... N ...	.. ..	Negative	Overgrown.
18	5 ,, ...	Guinea-pig, *Cavia Cutleri*, Bennet	Lungs pneumonic; no other lesions	Liver	N ...	Mixed	...	Negative	Pneumonia.
19	5 ,, ...	Mandarin Duck, *Aix galericulata*, Linn.	No definite pathological lesions	Liver Spleen Heart-blood	N ... N ... N ...	N .. N ... N ...	... ...	Negative.	
20	5 ,, ...	Wallaby, *Macropus sp.*	Bubo of right inguinal glands; hæmorrhages in liver, spleen, kidneys, suprarenal bodies, skin, lungs, heart, bladder contained blood-stained urine, peritoneum contained excess of fluid; slight œdema of chest wall; liver and spleen enlarged; decomposition commenced	Liver Spleen Right inguinal glands	P ... P ... P ...	Overgrown ,, ,,	P	Plague.	
21	5 ,, ...	,, ...	Bubo of right inguinal glands; hæmorrhages in skin, liver, spleen, kidneys, suprarenal bodies, stomach and intestines, heart, and lungs; bladder contained blood-stained urine; excess of fluid in peritoneal sac; liver and spleen enlarged...	Right inguinal glands Liver Spleen	P ... P ... P ...	... ... P ...	P	Plague.	
22	6 ,, ...	Native Cat, *Dasyurus viverinus*, Shaw.	Bubo of left submaxillary glands; hæmorrhages in skin, liver, spleen, kidneys, suprarenal bodies, stomach, and intestines, lungs, and heart; liver and spleen enlarged; decomposition marked	Liver Spleen Left submaxillary glands Heart-blood	N .. N ... Mixed N ...	... ...	N N N N	Negative	Bacilli resembling *B. pestis* in smear; not confirmed.
23	7 ,, ...	Guinea-pig, *Cavia Cutleri*, Bennet	No pathological lesions	Heart-blood	N ...	N ...	N ...	Negative.	
24	7 ,, ...	Rabbit-eared Perameles, *Thylacomys lagotis*, Reid.	Bubo of left axillary glands; hæmorrhages in skin, kidneys, suprarenal bodies; liver and spleen enlarged	Left axillary Glands Spleen Liver	N ... ... N .. N ...	... ...	N ... N N	Negative.	
25	8 ,, ..	Tiger Cat, *Dasyurus maculatus*, Kerr.	No bubo; hæmorrhages in skin and muscle, liver, suprarenal bodies, heart, glands; no excess of fluid in sacs	Heart-blood Liver Spleen	N .. N ... N ...	N ... N ... N ...	N N N	Negative	Pneumonia.
26	8 ,, ...	Opossum (brush-tailed).	No bubo; hæmorrhages scanty in skin, suprarenal bodies, heart	Heart-blood Liver Spleen	N ... N ... N ...	N ... N ... N ...	N N N	Negative	Pneumonia.
27	9 ,, ...	Martin (bird) ..	No signs of disease	Lungs Liver Spleen	N ... N ... N ...	N ... N ... N ...	N	Negative.	
28	9 ,, ...	Australian Eagle, *Aquila audax*, Lath.	No bubo or hæmorrhages; abscess of left thoracic region; pus cheesy	Heart-blood Liver	N ... N ...	N ... N ...	N ...	Negative.	
29	9 ,, ...	Indian Antelope, *Antilope cervicapra*, Linn.	Left inguinal glands enlarged, and surrounded by sanguineous œdema which resembled bubo; hæmorrhages in skin, liver, suprarenal bodies, and kidneys; stomachs, and intestines, heart, lymphatic glands generally; excess of fluid in peritoneal sac; marked inflammation of stomachs and intestines; decomposition very advanced	Liver Spleen Left inguinal glands	P ... P ... P ...	N ... N .. N ...	N	Plague ...	Overgrown.
30	9 ,, ...	Opossum *Trichosurus vulpecula*, Kerr.	No bubo; hæmorrhages in skin, inguinal and axillary glands, liver, kidneys, suprarenal bodies, heart; excess of fluid in peritoneal sac; pneumonic patches in both lungs; decomposition marked	Liver Spleen Right inguinal glands Lungs	N ... N ... N ... N ...	N ... N .. N ... N ...	... ...	Negative	Putrid

No.	Date.	Animal.	*Post-mortem* Appearances.	Bacteriological Examination.				Diagnosis.	Remarks.
				Specimen.	Smear Preparations.	Culture.	Result of Inoculation.		
	1902.								
31	10 May ...	Wallaby, *Macropus sp.*	No bubo; hæmorrhages in right inguinal glands (scanty), mammary glands, skin, stomach, and intestines, kidneys, suprarenal bodies, spleen, heart; excess of fluid in peritoneal and pleural sacs; liver and spleen showed numerous necrotic spots; broncho-pneumonia patches in both lungs	Liver Spleen	P ... P ...	... ...	... ...	Plague ...	Overgrown.
32	13 ,, ...	Mandarin Duck, *Aixgalericulata*, Linn.	No definite *post mortem* signs	Liver Spleen	N ... N ...	... ...	... ...	Negative	
33	13 ,, ...	Guinea-pig, *Cavia Cutleri*, Bennet.	*Post-mortem* signs of pneumonia; no indications of plague	Lungs Liver Spleen Heart blood	N ... N ... N ... N ...	... ...	... ...	Negative.	
34	13 ,, ...	New Guinea Monitor, *Varanus sp.*	Abscess in anal region; no indication of plague	Liver Spleen	N .. N ...	N	N ...	Negative.	
35	14 ,, ...	Syrian Goat, *Capra hirsus (var.)*, Linn.	Abscess in left submaxillary region; no hæmorrhages; pneumonic areas in lungs; had been sick for three weeks	Spleen Liver Lungs	N ... N ... N ...	N ... N ... N ...	N N N	Negative.	
36	14 ,, ...	Opossum, *Trichosurus vulpecula*, Kerr.	No bubo; hæmorrhages in right and left inguinal and axillary glands, liver, suprarenal bodies, kidneys, heart; excess of fluid in peritoneal sac; slight inflammation of stomach and intestines; pneumonic patches in both lungs	Liver Spleen	N ... N ...	N ... N ...	N ...	Negative.	
37	16 ,, ...	Macaque Monkey, *Macacus sp.*	No bubo; hæmorrhages in liver, kidneys, and suprarenal bodies; pneumonic patches in lungs; slight enlargement of mesenteric glands near caecum	Liver Spleen Mesenteric glands	N ... N ... N ..	N ... N .. N ...	N	Negative.	
38	17 ,, ...	Axis Deer, *Cervus axis*, Erxl.	No bubo; hæmorrhages in skin, right inguinal, axillary and mesenteric glands, liver, kidneys, suprarenal bodies, 4th stomach, intestines, and heart; excess of fluid in peritoneal sac; serous œdema under skin of ventral surface; decomposition marked	Liver Spleen Lungs Right inguinal glands	N ... N ... N ... N ...	N ... N ... N ... N ...	N	Negative.	
39	21 ,, ...	Macaque Monkey, *Macacus sp.*	No bubo; hæmorrhages in suprarenal bodies; slight enlargement of mesenteric glands near caecum; decomposition marked	Liver	N	Overgrown	...	Negative.	
40	24 ,, ...	Flamingo, *Phoenicopterus roseus*, Pallas.	No definite *post-mortem* signs	Liver Spleen Heart blood Muscle	N .. N ... N ... N ..	N ... N ... N .. N ...	... ...	Negative.	
41	2 June ...	Magpie, *Gymnorhina tibicen*, Lath.	Acute enteritis	Liver Heart blood	N ... N ...	N ... N ...	... ...	Negative.	
42	5 ,, ...	Coypu Rat, *Myopotamus coypus*, Molina.	No definite *post-mortem* signs	Liver Spleen Heart blood Right inguinal glands	N .. N ... N ... N ...	N ... N ... N ... N ...	N	Negative.	
43	7 ,, ...	Guinea-pig, *Cavia Cutleri*, Bennet.	Bubo of right inguinal glands; hæmorrhages abundant; superficial left glands generally; skin, muscle, mammary glands, stomach and intestines, liver, spleen, kidneys, suprarenal bodies, heart, lungs; excess of fluid in peritoneal sac; extravasation of blood into epicardium; liver and spleen enormously enlarged and showed numerous necrotic spots; similar spots in deeply congested broncho-pneumonic lungs	Liver Spleen	P ... P ...	P ... P ...	... ...	Plague ...	
44	7 ,, ...	Guinea-pig, *Cavia Cutleri*, Bennet.	Bubo of left inguinal glands; P.M. signs otherwise same as in No. 43	....	P ...	P ...	...	Plague ...	
45	10 ,, ...	Guinea-pig, *Cavia Cutleri*, Bennet.	Bubo of submaxillary region; hæmorrhages in skin, muscle, liver, kidneys, suprarenal bodies, heart; excess of fluid in peritoneal sac; spleen enlarged and showed abundant miliary speckling; pneumonic patches in lungs	Spleen	P ...	P ...	...	Plague ...	

170. From the preceding table it appears that the verified deaths from plague among the caged animals occurred as follows :—The first verified death happened on 12th April. During the next 28 days 7 others occurred, and they were separated from the first verified death and from each other by successive intervals of 12, 3, 8, 4, and 1 days. A long interval of 28 days then occurred, during which certain animals died in a number much above the usual average, though not of ascertained plague. Then one of the keepers was attacked (case 135, 5th June) with, and died (8th June) of, plague. The outbreak ended about the same time with three further deaths of animals from plague; these occurred among a small cageful of guinea-pigs on June 7 and 10.

171. Here it may be conveniently pointed out that susceptibility of marsupial animals to plague has now been noted for the first time. Natural infection of caged guinea-pigs has been noted in India.* Another observation worth recording here is the presence of buboes in most of the 11 caged animals which died of plague; our experience being that naturally infected rats never exhibit buboes. The cause of death of the first of them was determined by examination of the liver, which alone was submitted for examination; entire carcases were available in 10 other instances. Of these, 5 showed buboes in the left inguinal, 3 in the right inguinal, and one in the submaxillary glands, while the tenth had the disease in the septicæmic form, and exhibited no enlarged glands. These proportions and distribution were similar to those we have observed in man.

172. Here, then, we have an instance of infection with plague not merely of man, but also of lower animals other than rats. Only a minority of the animals was attacked, just as one only out of the 25 or 30 men working among them was attacked. The man who suffered was not a member of the cleansing-staff, but a keeper who, therefore, would appear to have been less exposed to danger than many others were who, nevertheless, escaped. Again, there was here a long interval of 28 days in the course of the epizoötic among the caged animals, just as we have seen long intervals occur in the course of epidemics (between cases 1 and 2, 1900; cases 1 and 2, and 2 and 3, 1902; on the Paddington and on the Alexandria areas, &c., &c.). These coincidences seem to betoken a similarity between the secondary causes of epizoötic and of epidemic plague. As to epidemic plague, such irregularities can be accounted for by reference to that secondary cause which consists in dissemination of the infection by rats; and I have attempted to induce the reader to observe that some of the more remarkable features of epidemic plague depend upon, and can only be explained by, the capricious way—irregular both in time and in place—in which infected rats gradually become distributed over populous areas which are covered with solidly constructed buildings. Does a similar explanation apply to the peculiar features of this outbreak of plague among caged animals other than rats? In order to answer this question the state of the Garden as to presence of rats, and as to occurrences of plague among them, must be examined.

173. On 21st February (case 25) a complaint had been made that the Garden was badly infested, and was a danger in relation to plague, by one of the public. The Board directed inquiry, and was informed that the place was believed to be comparatively free from rats; this information was unexpected, and afterwards turned out to have been incorrect.

174. On 7th May I examined every member of the Garden staff as to his experience with rats there; but it should be noted that the Superintendent alone slept on the premises, and alone, consequently, had opportunity of observing after sunset when rats were most likely to be visible. The Superintendent said that he had seen increased numbers towards the end of February, but added that during the long term of his superintendency he had noticed fluctuations from time to time, and he declined to attribute any special importance to the increase mentioned. Nevertheless, it appeared from his books that he had purchased an additional supply of traps on 5th March. One of the keepers also said that he had noticed an increase about that time, and had occasionally seen one or two dead rats lying about. Another keeper, whose business it was to attend to some birds, pademelons, kangaroos,

* The Bombay Plague: Compiled under orders of Government by Captain J. K. Condon, Indian Staff Corps. Bombay 1900, page 122.

kangaroos, and wallabies, which were kept in that corner of the grounds where the first deaths among the animals occurred, said that about the time the illness among the marsupials began he had found dead rats, 3 carcases one day, and 2 on another; and this was so unusual a circumstance that he at once reported it to the Superintendent (the Superintendent would not deny, but could not remember, that he had done so). Another keeper, who looked after the elephants and camels in another part of the grounds not far from the slaughter-house, said that, although he had been employed at the Gardens for six years, he had never seen more than a few rats altogether (that is, it will be remembered, by day); but that about commencement of the mortality among the caged animals he had come across a sick rat one day, which he had had no difficulty in stamping upon and so killing. The remainder of the staff, several of whom had been employed for many years, none for less than three, were unanimous in saying that they had not seen many rats at any time, and that they had never, or very rarely indeed, seen a single dead one. There is thus some evidence that one keeper had seen dead rats in unaccustomed number about the time the sickness among the caged animals began, and that somewhere about the same time another keeper saw an apparently sick rat in the open in the daytime.

175. A rat-catcher who had been detailed to secure specimens on 15th April had had very little success, though an experienced and trustworthy man. Between that date and 21st April, when systematic cleansing began, he had been able to submit only two rats, both of which were quite healthy.

176. Specimens were first submitted by the cleansing staff on 23rd April, and down to 3rd May it had forwarded 21 rats, none of which yielded any evidence of infection with plague on being examined in the laboratory. Down to this date the cleansing which had been done had been on the surface; rubbish had been collected, the soil of enclosures had been treated with carbolic acid, and cages and housing-sheds had been sprayed with hot lime-wash: but then some cages began to be moved so as to expose the soil beneath them. As soon as this was done considerably larger numbers of rats were discovered; and 2 out of 7 thus taken on May 3rd were ascertained to have died of plague. So also on 4th May, out of 3 rats one, on 5th May out of 5 rats 3, and on 6th May out of 31 rats 8 were ascertained in the laboratory to be infected with plague. The fact that, notwithstanding superficial appearances and inaccurate information, rats did infest the Garden in large numbers, and that plague was epizoötic among them, having been thus established, routine transmission to the laboratories of all carcases found was intermitted. Hence, although on moving cages and on digging out burrows they continued to be found in numbers, plague was not further demonstrated among them (was not looked for among them) until 7th June. A week or so prior to that date the yield of rats had fallen off, and had almost ceased; and, as has been mentioned already, no verified death from plague had been noted among the caged animals since 10th May, so that there was reason to hope that the infection had been cleared away. But immediately prior to 7th June fresh burrows and fresh carcases of recently deceased rats began to be seen again; they were observed under, and in the immediate neighbourhood of, a cage containing about 20 guinea-pigs. Smoking-out of the burrows with sulphur fumes, and digging-out, were again resorted to, and plague was again demonstrated in 3 of the rats then caught, as well as in 3 of the caged guinea-pigs which died between 7th and 10th June. The total number of rats examined in the laboratories was 76, and it was possible to identify plague in 19 of them.

177. It was thought that this falling off must have been due to some imperfection in the mode of search to that time followed, or to some incompleteness, but, nevertheless, that nearly all the rats and plague-rats must have been destroyed. But this was uncertain; it was therefore resolved that the surrounding fence should not merely be made good as regarded certain holes in it, but that it should be sunk beneath the soil to a depth of at least 2 feet all the way round, so that any rats which might remain should be confined to the enclosure, and so that outside rats should be unable to enter. This work having been speedily carried out, and all detected burrows having been smoked out or dug up without any more plague-rats having been discovered, it was thought that the Garden was free from infection, and permission to reopen it was given on 18th August.

178. It has already been mentioned that one of the keepers contracted the infection. He attended to some of the larger carnivora, of which the cages were on the same side as the guinea-pig cage, though 90 yards away from it; he was attacked on 5th June, and therefore had probably received the infection about 2nd June. He continued to be employed at his own work while the cleansing was going on, so that it would seem that many men (members of the cleansing-staff) had run much greater risks. The following are the particulars of his case:—

Case 134.—B.B., 24, m., single; a keeper at the Zoological Gardens, where he had been employed for three years and down to date of attack. His duty was to feed and clean some of the larger carnivora, wolves, wombats, and Indian swine. He had worked daily, Sundays included; occasionally he had done a little gardening, but not for several weeks before his illness. He lived at a house half-a-mile away, and left the Garden at night-fall. He was attacked at 3·30 on the afternoon of 5th June, with violent shivering, colic, vomiting, and diarrhœa. His case was reported about midday on 6th June, and he then exhibited a left inguinal bubo; presence or absence of wounds in relation to the bubo was not noted. In view of the circumstances I directed bacteriological examination of liquid withdrawn from the bubo to be made, and both morphological and cultural tests yielded positive results. He was removed the same day to hospital, and died 8th June. Specially careful examination was directed to be made of the house at which he lived. There were mouse-eaten holes in skirting boards on the ground-floor; all ground-floors were raised, but no traces of rats were found. Rat-catchers were told off to catch rats on the premises, but failed. The other inhabitants said that similar efforts had been made without success a few weeks before by rat-catchers in employment in this neighbourhood by the Local Authority for the City. At this house there were three contacts; there were no further cases, either there or at the Garden.

179. B.B. had had no communication with any previous case of plague, according to the result of inquiries on this head.

180. How had the Garden become infected? The larger carnivora were fed on horses which were slaughtered on the premises. The rest were fed on fodder which was furnished by a contractor, who procured his supplies by rail from the country; they were not distributed from his place of business in the Darling Harbour area, but were purchased by the Superintendent on the trucks in the railway yard, and were carted thence direct to the Garden. The same, I was informed, might be said of the maize, bran, pollard, potatoes, barley, and chaff, which formed other part of such supplies. Lastly, carrots, greenstuff, bananas, and some bread were supplied by a Chinese gardener at Botany. The information on these points was not precise, and probably represented merely the general rule.

181. The house nearest to the Garden at which a case of plague occurred stood 16 chains away. This was Case 100, and it occurred in a school boy who was attacked 18th April; he exhibited a left inguinal bubo; morphological and cultural tests positive; recovered. The house in which he lived with his parents was in bad sanitary state, and in poor repair; there were stables close to it; it offered every evidence of present infestation with rats; the inhabitants said they had complained to the Local Authority before the child's illness of bad smells in it as from dead rats, and the disinfecting staff removed 3 carcases from beneath the floors when they came to raise them. The nearest house beyond this at which any case of plague occurred was 60 chains away to the south-west, the next 84 chains away to the north-west; all others were still more remote, and the intervening country entirely covered with buildings. The nearest point at which a plague-rat had been taken was 72 chains away to the south-west. The patient was said not to have been away from his neighbourhood for many days before his attack, except on 6th April, when he had paid a visit to the Zoological Garden; but this, supposing the date correct, was 12 days before his attack, and, consequently, from 7 to 9 days before the date of his infection.

182. It thus seems possible that the last-mentioned patient's house became infected by invasion of plague-rats from the Garden, but also that the Garden was infected by invasion of city rats which travelled towards it across the area on which that house stood. If the latter had happened, it would be singular that no cases of plague in man, except this one, should have marked the progress of the rats, while on the other, it would not be surprising if migration in the contrary direction should have given rise to this one case alone. On the whole, our experience inclines us to favour the supposition that the Garden was infected first, and through imported fodder; but conjecture alone is possible.

DESCRIPTION OF A SINGLE INDIGENOUS CASE AT THE CITY OF NEWCASTLE.

183. Newcastle is situated at the mouth of the Hunter River, in S. latitude 32° 57′, 70 miles north of Sydney by sea. The population of the city municipal district was 14,250 at the Census of 1901, that of the city and adjacent suburbs 32,225. The tonnage entered during 1901 was 1,573,683. The principal occupation followed was coal-mining. One case of plague had been met with on a vessel in the port on 17th March (or five months before) which was imported from Sydney, and which has been elsewhere described (see p. 15).

184. T. O'N., 19, male, single, a native of this State, had been employed at the Criterion Hotel as cellarman and porter for four months; he had not been away from the neighbourhood during that term. He was quite well until he was suddenly attacked during the afternoon of 3rd August with severe headache, chilliness, and pains in the limbs. He went to bed, and on 4th August was visited by a medical man who advised his removal to the general hospital, where he was admitted the same day. During the ensuing night he was delirious, and on the morning of 5th August he had a temperature of 104°; he was seriously ill but nothing could be discovered to account for his condition. During the evening he first complained of pain in his left leg, and later an acutely tender swelling was observed in the left chain of femoral glands. Early on 6th August the case was reported to the Medical Officer of Health for the Hunter River Combined Sanitary Districts (Dr. Robert Dick, M.B., D.P.H.). Dr. Dick at once telephoned to the Department his clinical opinion that the disease was plague, and the Assistant Medical Officer of the Government (Dr. R. J. Millard, M.B., D.P.H.) was despatched to Newcastle to consult on the case with him. He arrived during the evening, and on the 7th expressed his concurrence with Dr. Dick's opinion. At a later hour Dr. Dick was able to report that the morphological and cultural tests which he had applied to liquid abstracted from the enlarged femoral gland had both yielded positive results, and afterwards that a guinea-pig which had been inoculated with a part of the same liquid had died of plague. Nurses having experience of plague were at once sent up, and all arrangements for transferring the patient to the Maritime Quarantine Station at Stockton were completed; but at the same time he grew rapidly worse, and he died at the general hospital on 7th August. The body was coffined with the precautions already described (Report, 1900, p. 21), and was buried on the Maritime Quarantine ground.

185. The Criterion Hotel was closed on 6th August, as soon as Dr. Dick's message had been received. It was placed under a police-guard instructed to prevent ingress of all but members of the household and lodgers. Dr. Dick was desired to obtain a list of names of all then living at the hotel, and to ascertain whence they had come; and as soon as all had been collected to inform them that they would be allowed to leave, but to permit none to go until their effects had been disinfected and their professed destinations ascertained. The licensee's family numbered 6, his servants 10, and the lodgers 18. The latter were almost all of them commercial travellers, and none had been out of the State for a long time past; many of them resided in Sydney, and none had had any discovered connection with plague there, where the last case had been notified two months before, on 12th June. All the visitors but one left on 7th August; no case occurred among them or at the hotel. As soon as the particulars mentioned had been ascertained egress and ingress were allowed to the occupants without any restriction.

186. After a preliminary inspection of the premises on the evening of 6th August, the Medical Officer of Health had reported the finding of a dead rat in a state of decomposition too far advanced for any useful examination, and that the licensee had said that shortly before T.O'N.'s illness he had found other dead rats. On 7th August the foreman of the Departmental rat-staff was directed to proceed to Newcastle, there to gather together a local rat-staff of twelve men, who were to catch rats in such neighbourhoods as might be pointed out from time to time by the Medical Officer of Health. Chief Sanitary Inspector Getting was also directed to proceed to Newcastle on the same date, taking with him apparatus and material necessary for immediate disinfection of the patient's room and the lodgers' luggage. He was accompanied by Temporary Sanitary Inspector Lobb, previously employed on similar duty at Sydney, and he was instructed to gather together a scavenging staff for cleansing of the premises, and of the neighbourhood afterwards.

187. At the same time the Mayor of Newcastle, as representing the Local Authority under the Public Health Act, for the City of Newcastle (with whom the Medical Officer of Health had already communicated), was officially informed of the nature of T.O'N.'s disease, and of the arrangements made for obviating the danger to which the city was exposed; and his assistance in furnishing labour and materials was requested. An advertisement was also forwarded for insertion in all the Newcastle newspapers, in which medical practitioners were requested to be good enough to refer doubtful cases with which they might meet to the Medical Officer of Health.

188. On 8th August, the hotel was occupied by the cleansing-staff. It was a large three story brick building, which stood at the corner of Hunter and Bolton streets, in the centre of the business part of the city. As a whole it was clean and well kept, and there were no signs of rats on the upper floors. But a large cellar under the bar was very dirty. It had a poor concrete floor, which was undermined by rats in all directions, and considerable quantities of rats' dung and rat rubbish afforded abundant evidence of recent infestation. It contained two shallow wells, apparently designed to collect subsoil waters draining from a steep rise on which the hotel stood; the upper well overflowed into the lower. The overflow from the latter escaped by an untrapped 9-inch e.w.g. pipe, which ran underground straight down the hill to the harbour front, where it discharged under wharfs at a distance of 9 or 10 chains from the hotel. This cellar was the principal place at which the patient was employed during the day; and it was learned that he had removed 8 dead rats from it shortly before he fell ill. During the cleansing 4 other carcases were discovered in it, but they were all too far advanced in decomposition for bacteriological examination. No live rats were observed.

189. At the wharves under which the drain discharged very large quantities of fodder had been landed during several previous months, either from ships or from the railway which ran along them; this had in large proportion been sent up from Sydney for transmission to the north, where it was wanted in consequence of a prolonged drought. It was almost or entirely the produce of this State, heavy duties having prevented profitable importations; but it had, no doubt, been exposed to incursions of rats during its collection at Sydney, where the last discovered plague rat had been taken on 11th July.

190. As soon as cleansing of the hotel, and of an adjoining ship-chandler's shop, which as regards rats was structurally one with the hotel, had been begun, a further cleansing gang was collected and organised by the Chief Sanitary Inspector, and it was placed under immediate supervision of temporary Departmental Sanitary Inspector Lobb, who had with him the Municipal Sanitary Inspector Lloyd; they were further assisted by Sanitary Inspector Abberton, of the personal staff of the Medical Officer of Health who directed the proceedings.

191. Authority of the Executive Government had already been procured for entering and cleansing the whole of the block which included the Criterion Hotel, and in the course of the next few days this work had been completed. The Local Authority then proceeded, as advised, to make a sanitary inspection of several other adjacent blocks in that part of the city which lies between Signal Hill and the railway viaduct, a distance of about 68 chains.

192. Destruction of rats had been carried on at Newcastle prior to the events now described. During the thirteen months, 11th May, 1900, to 8th June, 1901, a capitation grant of 6d. had been offered, and a furnace at which the rats brought in could be burned had been provided at a convenient spot; the number then paid for and destroyed was 32,581. This arrangement was resumed on 6th March, 1902, but the capitation grant was reduced to 3d.; between that date and 16th August, 13,103 rats were paid for and destroyed. During the four weeks ending 9th August the numbers thus brought in had been 255, 167, 169, and 83. The special rat-staff organised on 8th August was utilised, not for destruction of rats (although, of course, it incidentally destroyed them), but to collect them systematically from various neighbourhoods indicated by the Medical Officer of Health, so that the state of the rat-tribe generally on the area suspected of infectivity might be investigated. It began work on 8th August, but was not at its full strength of twelve men until 13th August. Between 8th August and 11th September it collected

rats

rats from 125 different premises which were well distributed over the whole area, many of them having been revisited several times. The number of rats collected was 1,598, and all were examined by the Medical Officer of Health. Two carcases alone gave ground for suspicion of plague; but the usual tests which were applied both by the Medical Officer of Health and by the Micro-Biologist to the Board of Health failed to establish presence of the disease. It must, therefore, be recorded that no plague-rats were found at Newcastle. Nevertheless, for reasons which have already been given above, it cannot be affirmed that there were no plague-rats there; and it is a significant fact both in relation to infection of T.O'N. and to arrest of it after occurrence of that single case, that no rumour of unusual mortality among the rats of any part of Newcastle was heard during the investigation, except at the Criterion Hotel.

193. No further cases of plague occurred, nor were any cases which presented good grounds for suspicion subsequently reported to the Medical Officer of Health.

Distribution of Cases among Plague-houses.

194. We are now in a position to examine the facts in relation to possible direct or indirect communication of the disease from man to man as a cause of the epidemic prevalence of plague more closely. The question, indeed, was examined fully in relation to the first epidemic (Report, 1900, pp. 31–33), and was in the clearest way answered in the negative; it will be well, nevertheless, to go over the evidence yielded by the second epidemic in order that this contribution to the ætiology of plague may be complete in itself, as far, that is to say, as it goes.

195. The following general statement has reference to houses which *harboured* cases, without regard to their having been or not having been the adjudged place of infection of such cases. The epidemic consisted in 139 cases; the patients inhabited 124 premises (including one ship); 15 out of the 139, therefore, were secondary cases. As the 15 secondary cases occurred on 9 premises, it follows that 115 separate premises (including one ship) harboured a single case apiece, and no more. The interval between attack and removal, or the number of days during which these 115 patients remained at home and in contact with the other members of the households to which they belonged was as follows:—

Table XX.—Showing the number of days after attack during which 115 primary-and-single cases remained in contact with the rest of the household to which they belonged:—

Removed on the day of attack	2
„ one day after attack	20
„ two days „	24
„ three „	24
„ four „	17
„ five „	8
„ six „	4
„ seven „	3
„ eight „	3
„ nine „	2
„ ten „	3
„ eleven „	1
„ twenty-three „	1
„ twenty-six „	1
Not removed	2
Total	115

Whence it appears that these 115 patients had, for the most part, opportunity of communicating their disease. Table XX corresponds with Table XII, Report 1900, p. 33, which is to precisely similar effect. Communication of the disease from person to person, if it ever occurred at all, was a factor of no importance whatever in production of the epidemic. We have, however, to examine the circumstances under which the 15 cases mentioned above occurred secondarily to, and on the same premises as, 9 primary cases.

Circumstances under which Fifteen Secondary Cases became Infected.

196. The datum for examination of the circumstances under which secondary cases received their infection, with reference to the possibility of their having got it from the primary case, is the time at which the primary case fell ill.

Table XXI.—Showing the dates on which nine primary cases began, and the dates on which fifteen cases secondary to them began.

Group.	Primary cases.—Numbers and dates of attack.	Secondary cases.—Numbers and dates of attack.
A	(3) Jan. 10–11	(5) Jan. 16.
B	(6) Jan. 19	(8) Jan. 20.
C	(24) Feb. 18	(30) Feb. 21.
D	(26) Feb. 19	(29) Feb. 21; (27d*) Feb. 22; (32d) Feb. 22; (31d) Feb. 23; (39) Feb. 24; (40) Feb. 25.
E	(35) Feb. 22	(45d) Mar. 1.
F	(52) Mar. 11	(53) Mar. 11.
G	(82) Mar. 21	(92) Mar. 29.
H	(85) Mar. 27	(91) April 2.
I	(112d) April 27	(117d) May 3; (126d) May 15.

* d = died.

197. *Groups A and B* (Paddington area).—These have been described elsewhere (see p. 22). Here only the following points need be mentioned:—First, Cases 3 and 5 of Group A were, of course, in intimate contact for ten or nine days of duration of Case 3; but the latter exhibited a right inguinal bubo, was at no date seriously ill, and recovered. Cases 6 and 8 of Group B were in contact for about twenty-four hours of duration of Case 6; the latter exhibited a left inguinal bubo, and recovered. Additionally, one or both of the patients constituting Group B had visited Case 3 one or more times. Secondly, the two groups occurred in adjoining cottages, which were separate for man, but structurally one for rats infesting either; and both were structurally one by the space under the floors with a third adjoining cottage, at which, as well as at the other two, it is known that a fatal disease prevailed among the rats infesting it.

198. *Group C* (Woolloomooloo area).—First, it must be assumed that there was free communication between Case 30 and Case 24 during the three days which elapsed before the latter was removed, since, although they belonged to different families, both inhabited the same small house. But Case 24 exhibited a left femoral bubo, and ended in recovery. Secondly, the house at which both lived was badly infested with rats, which, also, had recently died in numbers of disease; thirteen had been found dead between 15th and 17th February—four of them under the kitchen floor, one in the water-closet. Now, Case 24 was probably infected on 16th February, but the illness was not notified till 21st February; this was the day Case 30 was attacked, prior to which no cleansing had been done.

199. *Group D* (Criterion Hotel, Central area).—This group, according to Table XXI, consists of seven cases; but Case 27 was not secondary to Case 26, nor the remaining five secondary to Cases 26 and 27, for these two patients had left the hotel (where they had lived) before they fell ill. They are retained in the Table below partly to avoid confusion, but mainly for the sake of the light they shed on the true nature of the relationship between Case 29 and the remaining four. The following Table conveniently sets forth the important points. It is only necessary to emphasise the facts that Case 26 had acted as a temporary barmaid at the hotel, sleeping on the premises, from 10th February to 17th February; she had left in good health on the latter date, and was taken ill two days later at a house in a neighbourhood free from suspicion of infection, and without having had any further communication with the six later cases; and that Case 27, who had lodged at the hotel for several months before, left it on 19th February in good health for another hotel (which has never been suspected of infection), where she was attacked three days later.

Table XXII.—Showing the dates on which the seven patients who constitute Group D were attacked, notified, removed, and recovered or died; together with the situation of the buboes they exhibited.

Case No.	Sex.	Attacked.	Notified.	Removed from "Criterion."	Clinical form.	Situation of bubo.	Date of—	
							Recovery.	Death.
26	F	February 19	February 22	Had left 2 and 3 days before the attack.	Bubonic	R. inguinal	March 18	.....
27	F	,, 22	,, 22		,,	R. cervical	.....	March 2
29	F	,, 21	,, 22	February 23	,,	L. femoral	March 24	.....
31	F	,, 23	,, 24	,, 26	,,	R. inguinal	.....	Feb. 27
32	F	,, 22	,, 24	,, 25	,,	R. inguinal	.....	March 1
39	F	,, 24	,, 24	,, 26	,,	L. femoral	April 7	.....
40	M	,, 25	,, 26	,, 26	,,	L. inguinal	March 27	.....

200. It must be assumed that there was communication between Cases 29, 31, 32, and 39 after attack of Case 29, since they were all women living at the same hotel; but Case 40 occurred in a cellarman, and it is not likely he saw any of the women after they had been attacked. Nothing is known on this point. What were the other circumstances?

201. The premises were the Criterion Hotel and Theatre. They consisted of a fine corner block, four stories high, with a basement, of which part of the ground floor frontages was let as shops, &c. The three upper floors were clean. The ground floor and basement were in bad repair and dirty. These latter were ceiled and floored with wood, and subdivided with wooden partitions. When cleansing began and the partitions and linings were torn down, enough dung and rat's rubbish (paper, bones, rags, &c.) were removed to nearly fill two large scavenger's carts. Provision for drainage was inadequate, several inches of water having been found standing under the false floor of the ill-lighted and ill-ventilated compartments in the basement, some of which served as sleeping apartments for the servants. A similar state of things existed under the flooring of the first floor as regards rat's dung and rat's rubbish, of which large quantities were removed from between the joists. Upper floors had been gnawed through by rats at many points. From different parts of this building about forty-five dead rats were taken—from behind lining-boards and from under flooring boards in the basement; beneath kitchen, scullery, and pantry floors; from under a bedroom floor near a dining-room on the first floor; and from under three bedroom floors and a passage floor on the second storey. A bar-floor was riddled with rat-holes, and three carcases were taken from a box-seat behind the bar, another from under the counter, another from an adjacent urinal. All these carcases were too putrid for bacteriological examination, and no live rats were encountered; hence plague was not shown to have been the cause of this unusual mortality, which clearly had occurred during a few days only, since the carcases were in about the same stage of putridity. But plague was at this date present among the rats of the neighbourhood (*see* Central area, par. 133).

202. It is now apparent that the bond between Cases 26 and 27 severally and the remaining five was residence on these premises, and nothing else; for they were only attacked two and three days respectively after having left them for lodgings to which no suspicion of infectiveness at any time attached—one of them two days before Case 29, which was the first of the subsequent series. Next, it can be pointed out that Case 29 began 21st February, and that the four subsequent cases followed at intervals of one, two, three, and four days; but Case 29 not only exhibited a left femoral bubo and recovered, but also was removed within forty-eight hours of her attack. Note that Case 40 had in all probability received the infection on or before that date on which very energetic cleansing and disinfection of these premises had begun—namely, late on the afternoon of 22nd February.

203. *Group E* (Alexandria area).—Case 35 exhibited a left femoral bubo, and ended in recovery; during four days of its duration, Case 45 was in free communication with the patient. The house was a two-storey brick cottage in poor repair, where a pawnbroker's business was carried on. On being cleansed, large quantities of rat's rubbish and droppings were removed from beneath the floors which, as well as the skirting-boards, were full of rat-holes, but no carcases and no live rats were seen. There were many burrows in the yards, none of which were dug out. The neighbourhood was infected (*see* Alexandria area, par. 108). The second case may either have received its infection from rats which had been left in the burrows, or the house may have been reinfected from the neighbourhood after such cleansing as was done.

204. *Group F* (Central area).—The patients were a pantryman and a waiter employed at the Central Exchange Coffee Palace for a considerable time before attack. Both fell ill on the same day, one having been suddenly attacked "while at work," the other at 10 p.m. The premises were very extensive and constituted one end of a city block, having, consequently, frontages to three streets. The greater part of it was occupied by an hotel and by a photographer; other part as offices; the frontages at street level as shops. All parts of the building were in structural communication, so as to be free to rats. Sewerage was defective. A well, intended to light inner rooms of the building, had been filled with staging and covered over; the roof had been extensively built upon by the photographer, who had erected a very large number of rooms of odds and ends of wood, and had even built on the top of them again, the whole being full of lumber, dirt, and rubbish, except some filthy places in use. On cleansing, most parts of the building were found to be infested with rats, and large numbers of carcases, as well as nests, rubbish, and some live rats, were removed, but no plague-rat was identified. The two patients were partly employed in the basement, but slept in a kind of loft which was much overcrowded with ten other servants, and dark at midday. On the night they were taken ill, eighty people slept at the hotel, but no other cases occurred (but *see* Table XVII, in which Cases 60 and 69 are doubtfully ascribed to this building, which they visited regularly as an eating-house). There was here no possibility of communication of infection from Case 52 to Case 53 (nor from either of them to Cases 60 and 69, since the latter only went to the hotel about midday, while the former were suddenly attacked at night and incapacitated, and were removed during the forenoon of the next day, when, also, the building was closed to visitors).

205. *Group G.*—The first patient (Case 82) was a wharf-labourer in irregular employment; he fell ill 21st March, but worked on 24th and 25th March notwithstanding; he exhibited a left inguinal bubo, smears and cultures negative, and recovered; was removed to hospital, 27th March. The second patient was his son, aged 6, who fell ill eight days after him, and two days after his removal; glandular swellings, bi-cervical, acutely tender (slight reddening of fauces; no exudation) and bi-inguinal, of which slight tenderness on one side only; bacteriology, none; recovered. No note as to state of premises, which stood on the Chippendale area, the house being close to Jones's produce store at the back (*see* par. 84).

206. *Group H.* (*Pyrmont area*).—This was composed of Cases 85 and 91, mother and son. Case 85 was attacked 27th March, at 11 a.m.; left femoral bubo, smears and cultures negative; recovered; removed to hospital, 29th March. Case 91 occurred to the son, who was a printer's boy; no suspicion attached to his place of employment, which was carefully examined. He was attacked 2nd April, during the morning

at

at his work, six days after his mother, and four days after her removal; left femoral bubo, which appeared within four hours of onset; bacteriology, none; recovered; removed on day of attack. The cottage was cleaned on 29th March, the day Case 85 was removed; on taking up floors abundant signs of present infestation were found and much rat's rubbish removed, but no carcases; at least one dead rat had been found by the family a few days earlier. Next door to this house Case 83 had occurred 26th March. The patient was a labourer; he had a left femoral bubo, and a small reddened patch on the left instep, no pustulation; bacteriology, none; removed 27th March. A dead rat had been found by the patient a week or two before, but no carcases were found by the disinfecting staff. Case 85 was acquainted with this man, but said she had not been in his house for a week before his illness—a matter of little importance, true or not true, on account of the nature of his case and of his removal within twenty-four hours of his attack. But it seems that the disinfecting staff had not raised the floors at his house; for on occurrence of Case 91 they did this, and reported presence under them of every sign of continued infestation with rats, though they found no carcases. These three cases occurred on the Pyrmont area. On 26th March a plague-rat had been taken from the yard of a State school situated 160 yards away from these two cottages to the south-west, and three plague-rats were taken at Buckle's wharf on 7th, 8th and 10th April, which lay about 380 yards away from them to the west. No other case occurred within three-quarters of a mile of the cottages except Case 78, attacked 24th March at a rat-infested timber-wharf where many dead rats had been found; and Case 99, attacked 17th April, and Case 124, attacked 6th May, both at Buckle's wharf just mentioned.

207. *Group I.*—This consists of Cases 112, 117, and 126, which occurred in Chinese, all of whom died. The first of them was a man employed at Hop Lee & Co.'s produce store, 26, Campbell-street, on the South-Central area (and already mentioned, see par. 100); he was attacked 27th April, had the disease in septicæmic form, and died before notification at the entrance to Sydney Hospital to which he was in course of removal by his friends. Case 117 was attacked 3rd May; was admitted to the Royal North Sydney Hospital from a Chinese garden on that side of the harbour; his case was notified on 7th May, on which day, also, he died. He had pneumonia on admission and a submaxillary bubo, smears and cultures positive. This man had frequented Hop Lee & Co.'s during the week before his attack, and there seemed to be no doubt that he had also slept there; he was thus on the premises during illness of Case 112. Case 126 was attacked 15th May; the patient was taken to Sydney Hospital 16th May, but died on the way; nature of illness verified *post-mortem* under Coroner's order. This man was employed at Hop Lee & Co.'s. On notification of Case 112, the store was visited by the disinfecting staff, and was found to be well-constructed and in good order, but there were ill-lighted and ill-ventilated cubicles within the building, and more on the flat roof of a stable in the yard; abundant traces of present infestation with rats were found, but no carcases. The Local Authority for the city was advised to secure removal of the cubicles, but this was not done at that time owing to some misunderstanding. On occurrence of Case 118 the store was not revisited, for this patient's connection with it was not made out until after occurrence of Case 126; but it was revisited on occurrence of the latter, and although, again, no carcases were discovered, abundant signs of continued infestation were observed, and especially fresh droppings among pea-nuts stored over some of the inside cubicles. It has already been noted that a plague-rat was taken at a public-house six doors removed from this store on 22nd April (see par. 100).

208. These facts require no comment. It need hardly be pointed out that Group G presents elements of doubt as to the nature of the two cases, though the diagnosis was made and was confirmed by two physicians acting independently, both of whom had had long clinical experience of the disease; still it is to be regretted that no bacteriological check was applied to the second of them. In Group H the clinical signs were decisive; the negative result of the bacteriological examination which was made in Case 85 only was probably due to some accident, such as failure of the needle to penetrate a small bubo. I proceed to describe the instances in which multiple cases occurred in connection with premises at which none of the patients resided.

Circumstances surrounding the Infection of Four Groups of Persons associated solely by resort to the same Premises.

209. The foregoing groups, A to I, were made up of persons who lived at the premises where all of them are adjudged to have been infected (save two persons in Group A whose cases, as already noted, properly belong to this series; see par. 199). The following groups are composed of persons who in no instance lived at the place at which they are adjudged to have received the infection, but, on the contrary, all inhabited different houses in neighbourhoods which (with one exception) were distant or even remote from it, and which were also free from suspicion of infection with plague. In other words, the sole tangible bond between the persons of which these groups are severally composed was resort during business hours to the same business premises. Group K has special interest, since of the four persons composing

it, while two were employed at the theatre which was the adjudged place of their infection, two others merely attended a performance at it. The following table displays the more important facts :—

TABLE XXIII.—Showing the dates on which persons who constitute Four Groups, distinguished solely by resort to the same business premises, were attacked, together with some other particulars.

Group.	Case number and date of attack.	Adjudged place of infection.	Nature of association at and with adjudged place of infection.	Place of Residence.	Area in which residence situated—whether infected or not.
K	(21) Feb. 12	Her Majesty's Theatre and Hotel, 186–8, Pitt-street.	Attended performance.	Nelson-st., Leichhardt ...	Not.
	(18) „ 14		Employed ...	130 Reservoir-st, Surry Hills	„
	(19) „ 14		Attended performance.	22 Bullanaming-st., Redfern...	„
	(20) „ 15		Employed ...	247 Church-st., Camperdown...	Not till a month after attack.
L	(34) „ 24	Siddaway's Boot Factory, 47, Market-street.	Employed ...	59 High Holborn-st.... ...	Not.
	(43) „ 27		„ ...	Bondi	„
M	(64) Mar. 14	Andrew's Printing-house, 13, Bridge-street.	„ ...	38 Campbell-st, Balmain ...	„
	(65) „ 15		„ ...	14 Phelps-st., Surry Hills ...	„
	(66) „ 16		„ ...	26 George-st., Erskineville ...	„
	(71) „ 16		„ ...	Bexley	„
	(70) „ 17		„ ...	Kogarah	„
N	(99) Apr. 17	Buckle's Wharf ...	„ ...		
	(123) May 6		Frequented Buckle's Wharf.	6 Ultimo-st., Ultimo... ...	Yes.
				289 Riley-st.	Not.

210. *Group K (Central area).*—Her Majesty's theatre and hotel. The premises were very large, and had frontage to Pitt and to Market Streets. The theatre and the hotel were in communication for man only by a bar which was open to the latter on one side, to the dress circle on the other. This was not used as a passage. But for rats, these two establishments were practically one.

211. Case 21 occurred in a woman who was attacked 12th February, and who lived in a suburb 3 or 4 miles away, at a brick and weatherboard cottage, which was in fair repair, very clean, and free from all traces of infestation with rats. The patient said she had not been away from the neighbourhood of her dwelling for a long time prior to her attack, except 10th February, when she attended an evening performance at the theatre with her husband; they then sat in that part known as the family circle. No "indigenous" case occurred at any time within a mile of her residence.

212. Case 18 occurred in a boy who was regularly employed at the theatre, and who was attacked 14th February. His chief duty was to clean bottles and to keep in order a store-room at the back of the gallery next above the family circle, and in the evening to attend at a refreshment bar at the back of the family circle; he also sometimes helped to clean the auditorium. He went to this work at 7·30 a.m., continued till 4 p.m., went home and returned for the evening performance at 8 p.m., lastly getting home to bed at about 12·30 a.m. He lived in a brick terrace house, clean, in fair repair, and found to present no signs of infestation with rats.

213. Case 19 occurred in a man who was attacked 14th February. He was unemployed at the time, and from his account of his movements, which seemed to be straightforward and consistent, it appeared that he occasionally (though on what dates in relation to his illness, if any, was not made out) took food at 178, Pitt-street; that is to say, next door to No. 180, where a plague-rat was taken on 14th February. He lived in a brick house which was found to be dirty, damp, and in bad repair, but quite free from all traces of infestation with rats. No indigenous case occurred anywhere in the neighbourhood of his dwelling. On 11th February he went to the theatre, and then sat in the family circle.

214. Case 20.—This patient, who was attacked 15th February, was employed at the theatre as a scene shifter; he worked in the flies, and these were accessible both from the family circle and from the gallery; he was last employed on the day of his attack. For a description of his cottage and the state as to plague of the neighbourhood in which it stood, see Camperdown area (par. 136).

215. The theatre was separated from shops to the north of it on the Pitt-street frontage by a blind lane; the hotel kitchen was in the basement, and had a passage which led to this lane, by which wastes were taken out and deposited in boxes to be emptied by the scavengers; but similar access to the lane could be had from one or more premises to its north. From this lane putrid carcases had been gathered on 29th, 30th, and 31st January, and on 1st, 8th, and 11th February; and although almost unfit for bacteriological examination some of them were submitted to it. The general result was, that while morphological tests yielded doubtful, but occasionally apparently positive results, all cultures quickly became overgrown, and all

all inoculations yielded doubtful and untrustworthy results. Clear *primâ facie* evidence of plague in these carcases was got on 3rd February for the first time, and this was confirmed by the results of inoculation tests on 7th February. Further, plague-rats were taken on 14th and 25th February at premises within ten doors of the lane and on the same side of the way, namely, at No. 180 Pitt-street; so that it is plain that the neighbourhood of the theatre was freely infested with rats, among which plague was prevalent. Lastly, it need not be doubted that the plague-rats taken in the lane were thrown out from the hotel kitchen, perhaps altogether, but at least in part.

216. It has already been stated that, although ostensibly separate buildings, the theatre and the hotel were practically one for rats; especially, these animals had burrows which passed from the basement of the theatre, under the party wall, into the basement of the hotel where the kitchen was. But in general respects the two premises were found to be in good order. The sewerage and all the internal fittings had been reconstructed in 1900; the theatre was clean and, except the burrows referred to in the basement, no traces of rats were found until the family circle was reached; there cushions were both moth- and rat-eaten, and two carcases were removed from beneath the staging which supported the seats. In all, eight carcases were removed from the upper part of the theatre. In the wall of the family circle there was also a chase which carried a hot and a cold water-pipe, and a waste-pipe from a bath-room in the hotel, and which contained rubbish; under the floor of the bath-room two more carcases were found. However, the hotel was also found to be in good order and very clean except the basement, which was dirty; seven carcases in all were gathered from it. Lastly, the pavement in front of the theatre and hotel in Pitt-street, where it abutted against the external walls, was undermined by rats, these having gained access from a dry area. The undermining also extended in front of the Pitt-street face of the George Hotel a quite separate building which stood on the actual corner, and which was embraced by the theatre building, consequently, on two sides; here Case 22, attacked 16th February, occurred in a handy man, and on cleansing, although the place was clean and in good order, seven or eight putrid carcases were removed from it, as well as a good deal of rat-rubbish.

217. *Group L. (Central Area).*—Cases 34 and 43, attacked 24th and 27th February, occurred in two bootmakers employed at Siddaway's boot factory, 47, Market-street. These premises were less than 100 yards from Her Majesty's Theatre; it was not noted whether the two patients worked in the same part of this large establishment. The first of them lived about a mile away in a house which was free from all signs of infestation, and in a neighbourhood which yielded no indigenous cases; the second in a suburb several miles away which has at no time harboured any other case of plague, and in a house which was clean, in perfectly good order, and free from all signs of infestation. The first patient said that eight dead rats had been found and removed during a few days prior to his attack, and on cleansing the factory abundant traces of present infestation were found, and many carcases were removed from it.

218. *Group M. (North-central Area).*—This consists of five cases which occurred in men employed at Andrew's printing-house, 13, Bridge-street. All of them lived at houses which were ascertained to be rat-free; three of them in neighbourhoods at distances of from 1 to 3 miles, two of them in suburbs reached only by train at distances of 7 or 8 miles. The two latter had never harboured any case of plague, and no reason had appeared for suspecting that two of the former three were at any time infected. But the printing-house was riddled with rat-holes from basement to the top story; a history of dead rats found shortly before, and of the capture in traps of large numbers of live rats, was given by the workmen; eighteen carcases were removed by the disinfecting staff, and from between floors and ceilings, behind matched-board linings, and from other such places, no less than thirty-five loads of rat's dung, rat's nests, and general rat-rubbish were removed.

219. These and one other were the only premises in connection with which cases of plague occurred on the North-Central area, and it is convenient to refer here to Case 129, attacked 15th May, that is to say, two months later than any of the foregoing. The patient was a packer employed at a very large hardware store, who lived in a railway suburb which had never harboured any case of plague. The store was extremely well built and kept; all basements were of concrete, and all apertures were fitted with wire netting to aid in excluding rats. It had on one side of it a lane, on which Andrew's premises abutted. The latter were in so exceedingly bad a state that they were closed, and were repaired in a very leisurely way in consequence; so that at the date of attack of Case 129 rubbish was still being removed from them by way of the lane, which, of course, gave access to the hardware store as well. Careful inquiry revealed no other source of danger in Case 129; but it is quite possible the patient ran risks elsewhere.

220. *Group N. (Pyrmont Area).*—This consists of two cases which were separated by an interval of nineteen days. One was employed at, the other frequented, Buckle's wharf, at which plague-rats had recently before been taken, namely, on 7th, 8th, and 10th April, and from a wharf close by on 12th April; previously Case 78 had been attacked on 24th March, having been employed at a timber wharf next to Buckle's, where dead rats had been found in number. These were Cases 99 and 123. The latter patient, who had inhabited rat-free premises in an uninfected neighbourhood for thirteen days before his attack on 6th May, frequented this wharf for the greater part of a week before going by sea to the north of the State; he fell ill the third day after leaving. The little steamer in which he travelled had not only been fumigated and freed from rats before her departure, but was also on her first voyage; only two or three rats had been found on her. The wharf was in fair condition, but large quantities of produce as well as live pigs were landed there, and pig-yards and some stables were ill-constructed and dirty.

221. The last of these four groups, though probably entitled to its place in the list, is not as convincing as the other three, which, on the whole, furnish evidence of connection between plague-infection and premises, and between infective premises and presence of diseased rats, as good as can be desired. All the sufferers were

were united by one common circumstance, and by one only, namely, resort to the same rat-infested premises; in each group all were taken ill within three days of each other; none lived in infected neighbourhoods; and although it is true that all of them were free to visit infected neighbourhoods, yet the attack of all at about the same date excludes that explanation of their infection; lastly, no secondary case occurred at any of their places of residence, as distinguished from the adjudged places of their infection. So that while it is quite impossible, on the one hand, to surmise how it happened that the components of the three groups respectively came to be attacked at the same time, unless reference be made to the places of business to which they resorted; on the other the infection of plague is clearly enough shown to have existed in those places by the discovery of the carcases of dead rats in unusual number, and at a similar stage of putrefaction, at a time at which plague is known to have been epizoötic among the rats of the several neighbourhoods.

222. In connection with this short series (which corresponds with the series of 17 similar instances given in the Report, 1000, p. 35, Table XIII, but in much less detail) Case 14, Paddington area, should be recollected; in which the patient, who lived at a distance, fell ill rather less than three days after having cleared away rat-rubbish and two putrid carcases from beneath the floor of the house at which Case 13 had occurred.

Part III—The Epizoötic in relation to the Epidemic.

Introductory.

223. In all accounts of epidemic plague which have hitherto been published, the following causes have been recognised as efficient: (a) communication of the infection from the sick by direct and (b) by indirect means; (c) place-infection. By the two former the infection would be diffused, by the latter maintained.

The term "place-infection" is employed below in the sense in which it is used in India; this has has been mentioned above, (par. 36).

It seems to be now very generally admitted that communication of the infection from the sick occurs so rarely in the bubonic and septicæmic forms of the disease, that it might well be neglected in speaking of epidemic plague. But the singular lapse (pointed out by Hankin nearly five years ago) by which sufferers are regarded as no source of danger to others while they stay at home or at a near hospital, and yet are commonly regarded as the conveyors of the infection to clean places if only they travel away from home, seems (from the report of the Plague Commission in India; see also the footnote at page 37) to be still unrepaired. Nothing further is needed to show that the aetiology of plague is still a matter of doubt with a large majority.

224. These causes would amply suffice, of course, to explain the epidemicity of plague; and thus far the share which may be borne therein by rat-plague has been left in a position of undefined importance.

225. To refer to well-known reports on plague by English writers for example, the "History of the Progress of Plague in the Bombay Presidency from September 1896, to June 1899," although it contained very full references to Mr Snow's observations on migrations of rats and coincident spread of the epidemic in the same directions, nowhere suggested that the rat was the sole important cause of epidemic plague, and at the same time did rely on the other causes of spread which have been mentioned above. Secondly, the Report of the Indian Plague Commission, dated July 1901, merely admitted that sometimes rats might spread plague, and throughout represented direct or indirect communication of the infection from the sick and place-infection, as the prime causes of epidemic plague. Lastly, the Medical Officer to the Local Government Board, in his preface to Reports and Papers on Bubonic plague by Dr. Bruce Low, dated July 1902, discussed this relationship to which, he said, Dr. Bruce Low had given particular attention, and after consideration of the world-record submitted to him concluded that although it went "to confirm

"belief

" belief that, as regards plague, man and the rat are reciprocally infective, fail " completely in affording sufficient data for determining the degree to which man is " in danger through the rat."*

226. The difficulty of perceiving how the infection could be often conveyed from rat to man weighs heavily with some, no doubt, against the probability that epizoötic plague stands in causative relation to epidemic plague; yet at a very early date the practical efficiency of the rat in disseminating this infection oversea was generally asserted and admitted.

227. Nevertheless, Hankin had reviewed† certain epidemiological data in 1898, which had been gathered at Bombay, and had inferred that the incidence of plague on neighbourhoods and on houses stood in relation to their accessibility to rats, and not to any other of the several factors then and still commonly relied upon as secondary causes, such as filth, overcrowding, &c. &c.; and he had at the same time intimated his opinion that some intermediary insect was necessary to communicate the infection from rat to man. In the same year Simond,‡ after reviewing epidemiological data concerning the mode of spread of plague gathered in India, expressed his opinion that its epidemicity was due to migrations of plague-rats and not to human intercourse; at the same time he named the flea (and the bed-bug; but with the latter he was unable to experiment, and he assigned little importance to it *a priori*, having been apparently unaware that these insects are found in great numbers on rats, at all events in some parts of the world) as the intermediary insect which he, as well as Hankin, conceived to be necessary. Simond's hypothesis of the flea has indeed attracted very general attention, and perhaps there is now hardly anyone who is not aware of it, although in reality it was a secondary part of his paper. These contributions by Hankin and by Simond appear to me to be the only *epidemiological* contributions which have thrown much light on the aetiology of plague; and their weight lies, not in any theory as to the manner in which the infection is communicated from rat to man, but in exclusion, so far as their observations went, of infection derived from man as an efficient cause of epidemic plague. But this was overlooked, and the aetiology of epidemic plague remained obscure and, indeed, in confusion.

228. This result has followed in part—but, as the papers by Hankin and Simond have shown, in part only—from plague having occurred most often in eastern and other semi-civilised communities where accurate epidemiological observations hardly can be made. Hence the outbreak at Sydney in 1900 afforded a good opportunity of learning something exact of the mode in which plague spreads, from its having happened among a wholly civilised, white population, which lived under the same conditions of clothing and housing, of food, customs, social organisation, and local government, as are found in the cities of Europe. The Department was prepared to take advantage of it (see Report of the Board of Health on the case of A. P., Sydney, 7th February, 1900; or, Report 1900, Appendix L., in which the more important parts of that document were reprinted). Before occurrence of the first case (that of A. P.) inferences had been drawn from the reports so far published of the epidemics which had occurred or which were in progress in other parts of the world which differed in important respects from the opinions expressed by the historians themselves. By those inferences the action of the Board was guided, as has already been mentioned. And when the observations made and recorded during that outbreak came to be reviewed, it appeared that epidemic plague at Sydney had not been caused in any degree either by personal transmission of the infection, or by dissemination of fomites; and while it was rendered quite clear that place-infection could have played but an insignificant part at most in maintaining the infection, it seemed most probable that it had in reality played no part at all.

The only parts of the world, as far as I have seen, in which our observations of 1900 have been repeated by others, are Brisbane in Queensland, and Port Elizabeth in Cape Colony; at both of these places they seem to have been practically confirmed. At Brisbane, Dr. Halford§ during the epidemics of 1901 and 1902, and at Port Elizabeth, Dr. Blackburne‖ during the earlier half of 1901, were both able to exclude

* I much regret to find myself compelled to point out here that the account of plague in New South Wales which is given in the volume referred to (and of which I am in the best position to speak authoritatively) is erroneous in almost every detail of importance. † Annales de l'Institut Pasteur, 1898. ‡ *Ubi cit. sup.* § Report on 117 case of plague occurring in Brisbane in Sporadic Form; by the Medical Officer to the Metropolitan Joint Board, Brisbane, Q., 1902. ‖ Lancet, 11th October, 1902.

exclude diffusion of the infection by man, and to trace association between cases of plague and plague-rats as clearly as could be reasonably expected. Both, however, committed themselves to statements concerning the connecting link between rat and man which, it is most important to note, had not been at that date sufficiently supported by direct evidence, as I have myself elsewhere pointed out.*

229. These results constituted a step of which the importance has hardly been appreciated (W. Kolle alone, as far as I know, has perceived their bearing and weight: see Bericht über die Thätigkeit in der zu Studien über Pest eingerichteten Station des Instituts für Infectionskrankheiten, 1899–1900, Zeit. f. Hyg., 1901, p. 397). If under conditions which admitted of accurate observation the generally accepted causes of epidemic plague were seen not to have been in operation, some other cause was to be sought. For what had been thus pointed out was not merely the result of interference with the natural course of the disease by good management—such, for instance, as is implied in prompt removal of patients to hospital, and in prompt disinfection of their dwellings; nor could it be ascribed to generally favourable conditions of housing, feeding, work, and climate. Although it might fairly be argued that the comparative smallness of the total number of cases was due to those factors, yet the cause of the absolutely large number (303) which did occur still remained to be discovered. It was certain that the infection had not been diffused and maintained by man; how then had it been spread? Place-infection having been excluded by the facts, but one other means presented itself, and, in my opinion, but one other could be reasonably surmised. This was the rat, in whose body, and in whose body alone out of all places external to man's body, the infection had been shown to be commonly present.

230. If man commonly received the infection from the rat—if epizoötic plague were indeed the cause of epidemic plague at Sydney; then coincidence between plague-rats and plague in man on the same premises should be demonstrable, and (it seemed, *a priori*), easily demonstrable. But in the course of the review referred to we found that we had not demonstrated it. Dr. Tidswell had, indeed, been enabled to identify but 23 plague-rats throughout the epidemic, and none of them were obtained from premises which had yielded cases of plague in man. Or, if findings of putrid carcases in which the nature of the disease, which, evidently, had been the cause of death, could not be rigidly identified, be accepted as evidence of epizoötic plague (as under all the circumstances it reasonably may), then dead rats in number were only observed on about 70 premises, although 221 premises were the adjudged places of infection for 255 cases. But the reader who has perused the foregoing pages need not be told that, so far, at all events, there is no evidence that this discrepancy was a matter of fact; clearly it may have been apparent only, and may have resulted from the method of observation, which was certainly imperfect.

231. On recurrence of the disease in 1902, then, we were prepared by former experience to examine this relationship more closely, as well as to check the correctness of our earlier observations on the share taken by man, fomites, and place-infection in diffusing and maintaining the disease. It has already been shown that former conclusions regarding these factors have been completely confirmed. Besides this, further continuous observation and reflection have completely failed to suggest any other source of the infection than that furnished by diseased rats.

232. The ground, therefore, seems to be thoroughly cleared. All that remains is to inquire whether during the second epidemic improved methods of observation did or did not reveal such frequent and close association between plague-rats and plague in man as suffices to furnish a strong presumption that diffusion of plague-rats was the sole cause of the epidemic.

233. From the method of description selected, the reader is now in a position to judge in how far the connection referred to has been discovered, and in how far it deserves to be recognised as the essential condition which we are convinced it was. Here it is necessary only to mention a few numerical statements, to refer briefly to the more cogent facts already related, to trace the course of the epizoötic, and to advert to the conditions of observation in the field which—and which alone, I think—have caused the results, although improved upon those attained in 1900, still to remain defective. TIME

* Public Health, Vol. XIV, pp. 340–1.

Time and Place Relations.

234. In the first place, the following table, which necessarily begins with the epidemic of 1900, exhibits a certain general relationship in time between epizoötic and epidemic:—

Table XXIV.—Showing month by month the number of plague cases which occurred, and the number of plague-rats which were identified, during the epidemics of 1900 and of 1902, together with the interval which elapsed between the two; as well as a part of the plague-free time which followed on conclusion of the second outbreak.

Year.	Month.	No. of Persons infected.	No. of plague-rats identified.	Period.
1900...	January	1	.....	First epidemic.
	February	3	9	
	March	51	2	
	April	107	6	
	May	93	5	
	June	41	1	
	July	6	.....	
	August	1	.....	
	September	.....	.....	
	October	.....	.....	
	November	.....	.....	
	December	.....	.....	
1901...	January	.....	.....	
	February	.....	.....	
	March	.....	.....	
	April	.....	.. ...	
	May	.....	.....	
	June	.....	.....	
	July	.....	.....	
	August	.....	.....	
	September	.....	.....	
	October	.....	.....	
	November	1	4	Second epidemic.
	December	1	.....	
1902...	January	6	5	
	February	26	25	
	March	57	6	
	April	20	37	
	May	22	23	
	June	6	4	
	July	.....	1	
	August	.....	.....	
	September	.....	.....	
	October	.....	.....	
	November	.....	.....	
	December	.....	.....	
1900–2 Totals...		442	128	

235. In 1900 only 187 rats, selected from a recorded take between 18th April and 31st October, 1900, of 108,308, were examined in the laboratories. During the first interval (September, 1900, to November, 1901) only 237 were examined. From 16th November, 1901, to 31st March, 1902, the recorded number of rats taken by the Departmental staff and by the public (who again received a capitation allowance of 3d.) was 47,285, from which 1,730 were selected by the Departmental staff in accordance with the rough rules already mentioned (see par. 81), and were examined in the laboratories; 40 of them were found to be infected. From 1st April onwards all rats taken by the Departmental rat-staff were delivered at the laboratories, and were examined; the number from 1st April to 14th July, when the last plague-rat was identified, was 28,618, and 65 were found infected. From July 13th to December 31, rats collected from the wharf line within the city, from the city proper, and from adjacent municipalities, to the number of 25,664 were collected, and 12,051, being all that were taken by the Departmental staff, were examined in the laboratories; none of them were infected. From 1st January to 31st March, 1903, rats to the number of 4,254 were collected from the wharf line within the city, and from closely adjacent streets of the city only, and 3,952 were examined in the laboratories; none of them were infected. That is the evidence of general coincidence in time between occurrence of plague in man and finding of plague-rats.

236. It is also the evidence that at Sydney it did not appear that plague in a chronic form persisted among the rats after the apparent epizoötic had ceased.

237.

237. Secondly, the table below shows a general coincidence in place between occurrence of cases and findings of plague-rats.

TABLE XXV.—Showing the *indigenous* cases of plague which occurred in each of the 8 wards of the City of Sydney and in forty metropolitan municipalities, the number of rats collected in each district, and the number of plague-rats identified in each collection :—

	First Epidemic. 19th January, 1900—9th August, 1900.			Second Epidemic. 4th November, 1901—8th June, 1902.		
	Cases.	Rats.		Cases.	Rats.	
		No. Examined.	No. Infected.		No. Examined.	No. Infected.
CITY OF SYDNEY.*						
Bourke Ward	24	21	2	8	558	5
Brisbane „	56	28	13	12	1,759	17
Cook „	14	14	1	3	1,258	19
Denison „	31	14	.....	14	2,454	14
Fitzroy „	2	4	.....	2	1,080	2
Gipps „	16	9	.....	3	773	4
Macquarie „	22	4	1	28	600	13
Phillip „	14	1	1	12	261	4
SUBURBAN MUNICIPALITIES.						
Annandale	4	1	.....	.....	2	.....
Alexandria	.....	.....	.....	8	317	4
Ashfield	.....	.....	.....	.....	.....	.....
Balmain	.....	.....	.....	.....	565	.....
Bexley	.....	.....	.....	.....	.....	.....
Botany	.....	.....	.....	.....	150	.....
Botany North	.....	.....	.....	.....	48	.....
Burwood	.....	1	.....	.....	2	.....
Camperdown	2	.....	.....	2	332	5
Canterbury	.....	.....	.....	.....	.....	.....
Concord	.....	.....	.....	.....	.....	.....
Darlington	.....	1	.....	.....	233	.....
Drummoyne	.....	.....	.....	.....	3	.....
Enfield	.....	.....	.....	.....	.....	.....
Erskineville	.....	.....	.....	.....	66	.....
Glebe	6	.....	.....	.....	285	.....
Hunter's Hill	.....	.....	.....	.....	11	.....
Hurstville	.....	1	.....	.....	.....	.....
Kogarah	.....	.....	.....	.....	2	.....
Lane Cove	.....	.....	.....	.....	3	.....
Leichhardt	1	1	.....	.....	.....	.....
Manly...	9	48	3	.....	28	.....
Marrickville	.....	.....	.....	.....	15	.....
Marsfield	.....	.....	.....	.....	.....	.....
Mosman	.....	.....	.....	.....	7	.....
Newtown	.....	1	.....	1	346	12
North Sydney	.....	3	.....	.....	144	.....
Paddington	20	5	.....	9	1,120	3
Petersham	.....	.....	.....	.....	1	.....
Randwick	.....	1	.....	.....	17	.....
Redfern	25	2	2	1	946	1
Rockdale	.....	.....	.....	.....	5	.....
Ryde	.....	.....	.....	.....	.....	.....
St. Peters	.....	.....	.....	.....	15	.....
Strathfield	.....	.....	.....	.....	.....	.....
Vaucluse	.....	.....	.....	.....	1	.....
Waterloo	10	.....	.....	10	687	2
Waverley	3	3	.....	.....	90	.....
Willoughby	.....	.....	.....	.....	29	.....
Woollahra	5	15	.....	.....	45	.....
TOTAL	264	178	23	113	14,258	105†

* At the end of 1900 the city was divided into 12 wards. The earlier arrangement has been retained in this Table for purposes of comparison.

† Found on 40 inhabited houses (dwellings or places of employment), at 13 wharves, and in 6 streets, lanes, &c. ; or at 59 different places in all.

238. From some part of each of the 8 wards into which the city proper is divided (total area 2,880 acres, number of houses 21,137), all of which yielded cases, and from some part of each of those 6 of the 40 municipalities comprised in the metropolitan district which yielded cases of plague, plague-rats were collected. No plague-rats were got from districts in which no indigenous cases occurred. Neither were any got from districts into which cases had been merely imported; the extent to which the search was carried in such districts is shown in the sixth column of the preceding Table.

239. With assistance of the details already given (see Mode of Spread, p. 18), the general indication afforded by this table can be supported a little more directly. Thus, although Alexandria and Waterloo have a combined area of 1,830 acres, which carries 3,947 houses, the findings of plague-rats were confined exactly to those neighbourhoods in which the cases of plague were found; or, although Paddington has an area of 403 acres, which carries 4,386 houses, plague-rats were found only on that very small part (of about 16 acres, carrying 163 houses) which has been named the Paddington area, where the 9 (or 11) cases which constituted that sub-epidemic were found. Again, Camperdown covers 435 acres, and carries 1,503 houses, but plague-rats were identified only at premises in that street where the two indigenous cases of plague were met with. So also at Newtown, where the municipality covers 442 acres, and contains 4,521 houses, the only case of plague which happened there was found within half a dozen doors of the butcher's where a local manifestation of the epizoötic occurred, and at the same date. There is good evidence, then, of close association in place between plague cases and plague-rats.

240. Yet some evidence is required of closer association between cases and plague-rats; that is to say, of an association demonstrable in a preponderating proportion of individual cases. But the fact as regards such association is that whereas 113 cases have been adjudged to have been infected on 86 separate premises, and although plague-rats were identified on 40 inhabited premises (be they dwellings or places of employment), plague-rats and cases coincided but 4 times. Or, should that way of judging the facts be thought too rigid (as I have no doubt it is), then it can be stated that cases and the removal by the disinfecting staff of dead rats from the premises which were the adjudged places of their infection coincided only 47 times. This is a considerable proportion, though not large enough to be quite satisfactory; yet, although it may not be expanded, a much fuller statement of certain facts should be added to it, and considered in connection with it.

Notes on General Experience with the Epizoötic.

241. Experience has led us to regard the finding of several carcases at about the same stage of putrefaction on any premises, as evidence that disease has been at work (poison having been excluded). Further we recognise as evidence of death by disease not merely the carcases themselves, but the fact that they were found; for though rats die in the ordinary course from day to day their bodies are rarely discovered, and are even rarely a cause of nuisance. It has to be borne in mind, therefore, that the above-mentioned proportion of plague-houses from which dead rats were removed is ruled by the requirement that in order to form acceptable evidence of disease several carcases must be found; but for this precaution the proportion of such premises to indigenous cases would stand higher. Secondly, the evidence of infestation of premises consisted in rat-holes, rat-runs, and rat-rubbish (paper, bones, rags, straw, &c.) accumulated between floors and ceilings, between double partitions, and in other such places; while evidence as to recency of the infestation was furnished by the state as to moistness of the rats'-dung discovered, as well as by the actual finding of rats or of comparatively fresh carcases. Then, there was strong evidence of infestation in the case of 61 places of residence, of 23 places of employment, and of both in 3 others; that is to say, all these patients either lived or worked, or both lived and worked, in close association with rats, while in the case of 47 adjudged places of infection it was plain that the rats had lately been killed by disease. That disease was identified with plague on premises which yielded plague-

plague-cases 4 times only; the carcases having been in all other instances too far advanced in putrefaction for that rigid bacteriological examination which alone, I consider, warrants use of the word "identified."

242. Here it should be additionally noted on the one hand that a minority of total premises are rat-infested, and on the other that the presence on inhabited premises of plague-rats is far from being necessarily accompanied by cases in man. For instance, no cases occurred in connection with 36 of the 40 inhabited premises mentioned above on which plague-rats were identified; and Jones' store (par. 84) affords a striking example of this. But I have already pointed out that after examination of all the available facts it appeared that mere association with plague-rats does not suffice, apparently, to infect, and that "something further, and something not commonly existent, seems necessary to enable communication of the infection from the source to man . . ." (Report, 1900, p. 36). Our more recent, and more fully recorded, experience likewise obliges us to suppose that infection with plague is the result of a chain of circumstances which, on any individual premises, is seldom complete in all its links.

243. If epizoötic plague stand in causative relation to epidemic plague it must precede the latter. It is probable that this was the case in 1900, but we did not actually ascertain it. Probably it was the case in 1902, but, again, it was not actually ascertained. The bare facts are that Case 1 was attacked on 4th November; that a rat search began on 16th November; and that a plague rat was taken at one of a line of wharves, at which produce was habitually landed, on 18th November: while the case occurred in connection with a produce store at which presence of a fatal epizoötic among the rats which infested it was observed on 14th November, which epizoötic was proved to be plague. Yet it is hardly possible to mistake the meaning of this chain of events, although they do not constitute a proof. The patient certainly did not infect the rats at the store, for he was suddenly taken ill shortly after reaching it for work as usual, and immediately went home again. It is quite clear, however, that plague among the local rats preceded the occurrence of cases on the Paddington area; on the Alexandria area it must have done so, because, on examination of the patient's store within 48 hours of his attack, only putrid carcases in considerable numbers were found; some other and similar instances have been already mentioned above. Again, it was ascertained to have preceded attack of all cases together (except the first, which very strictly speaking must be excepted for want of demonstrative proof) and by five weeks or thereabouts.

244. It is now necessary to remind the reader that all these gaps in the evidence are not defects in fact, but evidently are due in a large measure—I think they are entirely due—to those practical difficulties which have already been mentioned (see pars. 114–5–6). It was said above that it had appeared, *a priori*, that coincidence on premises of the disease in rats and in man should be easily demonstrable. That such a coincidence did occur very often I do not doubt; but, after making prolonged attempts to follow the course of the epizoötic by methods which were modified from time to time, I am able to assert that this business is an exceedingly difficult one in any city. Briefly, the only methods of search thus far appearing to be practically available ensure, almost exclusively, the capture of healthy rats. The reasons have been sufficiently explained above. We must resort, then, to the teaching of those instances in which multiple cases occurred either at places of residence or at places of employment. Similar instances constituted the most weighty part of the Report on the Epidemic of 1900, in relation to the point under consideration; but those now referred to, having been much more minutely recorded, speak, I think, unmistakably. I do not hesitate to say that the case of the Criterion Hotel, Central area, alone would warrant a confident assertion that the doubts and hiatuses which the record of the epidemic in general and on particular areas shows, must be the result solely of inacquaintance with all the circumstances. This, however, must be left to the reader's judgment, to which it is submitted without hesitation.

245. I conclude this section with a record of some general observations on the course of the epizoötic. Transport of the disease *per saltum* has already been noted. From the centres of infection thus established it spread, as observed in 1900,

by

by continuity; and, since it can be thus transported, it follows that any district which has become infected thus or otherwise may be reinfected, or infected in another part of it, by the same means at some later date; and it may be thus reinfected not merely from the local *fons et origo* (which we consider was in both of our epidemics that particular line of wharves on the eastern shore of Darling Harbour, which—again, we consider—was on both occasions infected from places oversea), but also from any other infected district with which it is in the requisite kind of communication. The requisite kind of communication, or that which is most favourable to transport of the infection, appears, as a matter of observation, to be the distribution of fodder.

246. Plague is commonly represented as spreading among the rats of a district with extreme rapidity, and as exterminating them almost. Contrary to reported experiences in many other countries, sick rats have not been often seen in the open at Sydney. The instances cited by more or less trustworthy witnesses were not more than four during 1902, and with one exception it was said that only one sick rat at a time had been seen. Figures which have been given already show that the finding of plague-rats by the ratcatchers (particular premises being excepted, and reference made merely to buildings and their curtilages which were examined in the ordinary course of the night's work on infected areas) was not common. On certain badly-infested premises the disease has been seen to rage, and to exterminate the horde apparently—at Exton's, and Huxley's, and Goff's stores, for instance. In those cases the epizoötic was apparently over as regards those houses before the examination began. In another instance—at Jones's store—it seems that early information enabled the examination to be begun before the outbreak had long existed. Not merely were live rats found in number; but carcases were fresh, and there was no difficulty at all in identifying the disease. Rats usually retire from places where the horde has met with misfortune; but from this it would seem that they do not always do so quite so promptly as has been supposed. But such findings of carcases in great numbers were few, and were entirely confined to badly-infested, confined premises; while the carcases picked up in streets and lanes were almost always putrid, and beyond reasonable doubt had been thrown out from premises on which they had died. Here, then, we have seen the epizoötic rage with exterminating violence; but the case of the "Antillian" goes to show that very close quarters (or some other circumstance, possibly of quite another kind) are necessary. The outbreak among the comparatively few rats which that vessel carried—probably not more than 100 originally—appeared to be still in course of making slow progress when it was detected.

247. Then, again, we have no evidence of rapid spread over neighbourhoods. Cases of plague, of course, most certainly draw attention to the state of the local rats, and plague among the latter is (we think) attended by cases in man only in a small minority of instances; so that it is probable that a larger proportion of rats was affected than we have actual evidence of.

248. On the whole, the following opinion may be ventured:—The disease is much more frequently communicated from rat to rat than it is from rat to man, or from man to man (which latter is so uncommon as to be negligible, if primary plague pneumonia be excepted); and as the disease in the rat is a septicæmia, it can hardly be much more easily communicable between rat and rat by mere contact than it is between man and man, of which, also, laboratory experience affords direct evidence (see Further Observations on the Mode of Infection, p. 65). Hence I suspect that, as in the case of man, some special circumstance is requisite. I do not know what this is; but Dr. Tidswell has been struck in this connection with the fact that during the epizoötic fleas were abundant on all the rats brought to the laboratory, while as soon as evidence of its continuance had failed, fleas became so uncommon on the rats, which were still brought in in large numbers, as to be quite insufficient for purposes of the laboratory collection (see Ecto-parasites of the Rat, p. 71). The abundance of fleas on rats during continuance of the epizoötic was not specially associated with illness of the animals; it was generally observed, and on those which were perfectly healthy as well as on others.

Species of Rats Affected.

249. As to the species of rats affected, Dr. Tidswell has made the following note :—

With the exception of a single specimen of the Australian water-rat (*Hydromys*), which was found to be perfectly healthy, all the rats received belonged to one of two species—*Mus decumanus* and *Mus rattus*. No record was kept of the actual numbers of each. In the whole collection there were about as many of one as of the other; but *Mus rattus* predominated among those taken along the shores, and *Mus decumanus* among those taken inland. The infected specimens were all *Mus decumanus*. The rats taken from the "Antillian" were all of this species. I have not found plague in *Mus rattus*, although this species was readily infected in the laboratory.*

Mode of Infection.

250. After association between plague-rats and cases in man has been demonstrated sufficiently often to furnish a strong presumption that the epizoötic might have stood in causative relation to the epidemic; and after this presumption has been strengthened by the observation that whenever there was reason to believe that the important facts were fully known the epizoötic preceded the occurrence of cases in man, a difficult problem presents itself. This is, how the infection can be communicated from rat to man; and, after that has been shown, how it can be so communicated sufficiently often to give rise to an epidemic. The mode of infection in plague is discussed by Dr. Tidswell in the following paragraphs :—

"*Further Observations on the Mode of Infection*," by *Frank Tidswell, M.B., M.Ch., D.P.H., Micro-Biologist to the Board of Health.*

251. The subject of the mode of infection was previously discussed (Report, 1900, Appendix A) under the sub-headings of (*a*) inoculation, (*b*) ingestion, and (*c*) inhalation. It was shown that experimental animals such as rats and guinea-pigs had invariably succumbed to subcutaneous inoculation; and that they sometimes became infected by feeding; whilst the few experiments concerning inhalation had given negative results. Except in the matter of inhalation with which some other investigators have reported successful results, and upon which our own observations are too few to afford valid data, the issue of these experiments was in general accord with similar experiments made elsewhere. Further, they have their counterpart in epidemiological observations. For according to current belief the acquisition of plague by ingestion, if it occur at all, is not epidemiologically operative, whilst inhalation is held to afford the mode of entry only in the pneumonic form of the disease. On the other hand, the outcome of our local experience is in keeping with the general tenor of available reports in ascribing the overwhelming majority of attacks to inoculation of the bacillus of plague through some part of the external surface of the body. Accordingly the questions of infection by inhalation or ingestion have been left in abeyance, and the laboratory observations since made have been directed towards the elucidation of the manner in which the micro-organisms of plague effect their passage through the skin.

(*a*.) *Infection through slight skin lesions.*

252. In the former report it was mentioned that some of our patients showed wounds or abrasions of some part of the skin within the lymph-collecting area of the bubo; but that in all instances in which material from such lesions was examined no plague bacilli were detected in it. On the other hand, attention was directed to facts which showed that plague could be acquired through small wounds of the skin, *e.g.*, the cases of certain medical men in India and China who became infected through wounds incurred whilst making autopsies of plague cadavers. It was reported, by way of experimental support in this matter, that the test animals used in this laboratory had always died after subcutaneous inoculation of cultures or plague infected material, and an instance was given in which death followed so small a lesion as a prick with an infected needle. It may be added that culture material applied to a lightly scarified area of a guinea-pig's skin has been found to be followed by infection.

253. More recently information has come to hand of the observations of Weichselbaum, Albrecht, and Ghon, confirmed by Kolle (Zeitschrift für Hygiene, XXXVI, p. 397), that guinea-pigs succumb to plague after the application of culture material to a shaved area on the abdominal skin. Repetition of this experiment was successful in the three instances in which it was tried in this laboratory, but only on condition that the culture material was applied immediately after shaving. In four other instances, when the animals were allowed to remain twenty-four hours (3) and seventy-two hours (1) after shaving before the application of the culture material, the animals all remained unaffected. The first three animals serve as controls to the last four as regards virulence, for they were inoculated from the same cultures at the same times. Five similar experiments were performed by application of the material to the shaven thigh of guinea-pigs. In three, the application was made immediately after shaving; one died on the fifth day from plague; the other two remained unaffected. In another animal the application was made in twenty-four hours and the animal died on the fourth day; no plague bacilli were found in the tissues and the isolation of *staphylococcus pyogenus aureus* and *staphylococcus pyogenus albus* from the blood, liver, and spleen showed that death was due to ordinary septicæmia. The remaining guinea-pig of this series underwent the application seventy-two hours after shaving and remained unaffected by it. In a third series of animals the application was made to a shaved spot on the head. Of two of them to which the application was made immediately after shaving, one died, the other remained unaffected. Two others

 receiving

* But, since this was written, naturally-infected specimens of *Mus Rattus* have been found on one premises only.

receiving the application in twenty-four and seventy-two hours respectively after shaving, remained unaffected. The total result of these experiments was that five animals succumbed to the plague; three after application of the material to the abdominal area, and one each after its application to the thigh and head respectively. In all cases these animals received the application immediately after shaving. In the remaining cases where an interval of twenty-four hours or more elapsed between shaving and the application of culture the animals did not die of plague. In all the fatal cases there was evidence of local re-action in the formation of tiny vesicles (*phlyctenules*) upon the infected shaved areas. The essential details of the experiments are given in the following table:—

TABLE XXVI.—Showing the results of application of culture of *bacillus pestis bubonicæ* to shaved areas of guinea-pigs.

No.	Part shaved.	Time culture applied after shaving.	Result.	Remarks.
1	Abdomen	Immediately	Died 3rd day...	Phlyctenule 2nd day; inguinal bubo; P. bacilli in tissues.
2	" ...	" ...	" 8th " ...	" " "
3	" ...	" ...	" 3rd " ...	" " "
4	" ...	24 hours ...	Unaffected.	
5	" ...	24 " ..	"	
6	" ...	24 " ...	"	
7	" ...	72 " ...	"	
8	Thigh ...	Immediately	"	
9	" ...	" .	Died 5th day...	Phlyctenule 3rd day; inguinal bubo; P. bacilli in tissues.
10	" ...	" ...	Unaffected.	
11	" ...	24 hours ...	Died 4th day...	No phlyctenule; no bubo; pyogenic cocci in tissues.
12	" ...	72 " ...	Unaffected.	
13	Head ...	Immediately	Died 10th day..	Phlyctenule 3rd day; cervical bubo; P. bacilli in tissues.
14	" ...	" ...	Unaffected.	
15	" ...	24 hours ..	"	
16	" ...	72 " ...	"	
17	Abdomen	Control ...	Died 5th day...	Subcutaneous injection; inguinal bubo; P. bacilli in tissues.

254. The shaving of the guinea-pigs was performed in the ordinary way after lathering with soap; the shaved area being afterwards washed clean with sterilised water. Antiseptics were not used in view of their presence vitiating the results. One's personal experience of the smarting occasioned by the application of cosmetics (*e.g.*, Bay rum) to the recently-shaven chin and the associated suggestion of denuded epithelium led to the shaved areas of the guinea-pigs being carefully examined with the aid of a hand lens for evidence of minute lesions. No animal showing actual small cuts or oozing points was used in the above experiments. But short of actual penetration of the skin there were usually to be seen small red points—capillaries showing through the partially-removed epithelium—and the whole area presented the appearance of superficial denudation of epithelium. The material on the razor contained an abundance of epithelial cells, and no doubt, from a histological point of view, the amount of epithelium removed would be pretty considerable. It is to be concluded that the shaved skin is not intact: it is rather the site of a mild abrasion. From the results presented above—the lethality of immediate and innocuousness of later applications—it appears that even this slight abrasion causes enough impairment of the protective function of the epidermis to permit, when recent, the passage of bacteria to the deeper tissues, but that in the course of twenty-four hours the injury is sufficiently repaired for such invasion to be successfully resisted. Physiological considerations no less than actual experience suggest that the passage of plague bacilli through the skin is conditioned by the presence of a lesion of the epidermis at least, but the foregoing observations indicate that the necessary lesion may be very minute.

255. Presuming that minute or gross lesions, such as would suffice for the entrance of plague bacilli, are commonly present upon the human skin, there still remains, as an essential factor for infection, the contamination of the lesion by plague bacilli. In exceptional instances the contamination results from actual contact with infected persons or rats, but in the great majority of cases neither of these conditions obtain. For the mode of infection under review to be epidemiologically operative, the bacilli must be capable of extracorporal existence upon such materials as might gain access to the lesion.

(*b*) *Viability of bacillus pestis upon inanimate materials.*

256. The possibility of plague being acquired per medium of soiled articles led to the following observations being made in this laboratory with the object of determining how long the bacilli could survive upon such articles under the climatic conditions met with in this country. The method followed was to infect portions of various materials, remove them from the source of infection, and subsequently ascertain by culture how long the bacilli remained alive in them. The materials were initially sterilised and then infected by soaking them with broth emulsions of agar cultures of bacillus pestis. They were placed upon unglazed porcelain slabs enclosed within double glass dishes. Samples of each were removed at intervals of one or two days and placed in bouillon tubes, then incubated for twenty-four hours, after which subcultivations of the bouillon were made upon agar tubes. The usual bacteriological checks were made of the initial sterility of the articles used and of their subsequent freedom from extraneous contamination, as well as of the identity of the bacteria in the ultimate cultures. Three observations had to be rejected on account of miscarriage of the precautions and contamination at some stage or other, but otherwise no difficulty was experienced in carrying the tedious observations safely through to the end. In view of the fact that many observers have stated that the bacillus is readily killed by drying, the various

various experiments were arranged so as to display the results when the materials were dried rapidly, dried naturally, dried slowly, and kept wet. The first was effected by placing the dishes in the incubator, with a layer of cotton-wool between the upper and lower dishes; the materials all appeared to be dry in about twenty-four hours. The second could not be exactly obtained, since the materials had to be kept in the dishes to avoid contamination, and thus their drying was retarded to some extent; but no special measures were taken to keep them moist, and the materials dried in different periods during the course of a week or two. The third process was effected by placing the porcelain slab on slightly-moistened cotton-wool, which kept the glass chamber moist for a time, and delayed the drying of the materials for two or three weeks. In the fourth case the slab was placed on wet cotton-wool, and the materials did not become dry during the period of observation. With the exception of those incubated, the materials were kept at the temperature of the laboratory and exposed to ordinary light. It is to be noted that the materials received with the bacilli a certain amount of organic material (*bouillon*) which could serve them as pabulum, and such as would be present if the articles had been soiled by infected bodily secretions. The conditions were unnaturally favourable to the survival of the bacilli, in that they protected them from competing saprophytic bacteria. The materials chosen for observation comprised dust from the corners of floors and shelves of dwellings, and from the floor of a produce-store; grain and other produce; clothing materials (linen, cotton, flannel, tweed, &c.), and packing materials such as straw, wood-fibre, and saw-dust. The results of the observations are shown in the following table:—

TABLE XXVII.—Showing results of experiments to ascertain the extracorporal viability of bacillus pestis upon specified materials.

No.	Material.	Number of Observations.	Number of days Bacilli survived in Material.			
			Rapidly dried.	Naturally dried.	Slowly dried.	Kept moist.
1	Dust of dwelling—corners and between flooring boards	6	1	3, 4, 11	21	15
2	„ shelves	1	.....	.....	2	.....
3	Dust of produce store—floor	1	.....	.....	11	.....
4	„ street	6	−1	3, 3, 10	15	13
5	Grain—wheat	6	1	3, 4, 4	7	11
6	„ maize	5	1	3, 4	7	9
7	Potato parings	3	.....	3, 4	11	.....
8	Carrot parings	2	.....	4	15	.....
9	Peameal	5	1	4, 5	7	11
10	Bran	1	.....	.....	15	.....
11	Flannel (old washed material)	3	.....	3, 4	7	.....
12	Silk (old washed material)	3	.....	3	11	7
13	Muslin (new material)	4	−1	3	21	12
14	Cotton (new material)	5	2	4, 5	15	11
15	Linen (old material)	4	1	3, 4	5	.....
16	Jute sacking (old material)	5	2	4, 5	15	10
17	Tweed (old material)	1	.....	.....	15	.....
18	Serge (old material)	2	1	.....	.....	15
19	Straw	4	−1	1, 4	21	.....
20	Wood fibre	5	.....	3, 4, 9	5	7
21	Sawdust	5	1	4, 5, 9	15	.....

257. The fact that the bacilli died out in periods varying from less than one day to three weeks, may be taken as indicating that their extracorporal existence is a matter of survival rather than of continued viability. For, as already stated, the materials were soaked with nutrient broth, such as would have supplied the bacilli with abundant food under the condition of artificial cultivation. The issue of the different series of observations shows that the bacilli are markedly influenced by drying. In materials rapidly dried the bacilli survived usually not longer than 24 hours, sometimes less, rarely more; and never longer than two days. In materials drying naturally the bacilli survived usually three or four days, in a few instances for nine, ten, or eleven days. In material drying slowly they survived usually for one or two weeks, and exceptionally for three weeks. In all these instances their extinction seemed to be associated with the drying of the material, but the data contained in the last column of the Table indicate that excessive moisture is not greatly favourable to their continued existence. These various results are in accord with those previously reported (Report 1900, p. 55), and generally with those reported by other investigators.

258. The chief interest necessarily attaches to the results of those experiments which most closely simulate natural conditions. In so far as those dealing with naturally and slowly dried materials may be regarded as fulfilling these conditions, they indicate that the bacilli may be expected to survive on inanimate materials for three or four days as a rule, and that they can survive for as long as two or three weeks in diffused daylight, and at the ordinary indoor summer temperature in this city. But it has to be remembered that the experimental conditions are in fact more favourable to the bacilli than strictly natural ones would be, so that the indicated survival is probably in excess of that which would obtain in nature. It is accordingly to be inferred that such materials can only serve as the means of disseminating plague for usually not longer than three or four days, but exceptionally for two or three weeks after becoming contaminated with plague bacilli.

259. It does not seem likely in view of these results that the infection was brought to us with merchandise from oversea, nor that the second epidemic arose by redispersal of infection remaining latent after the first epidemic. But they do not in themselves exclude infected articles from having had some

share in the local dissemination of the disease. The survival of the bacilli is long enough, in dust and clothing for example, to admit of their carriage therein to lesions such as those mentioned in the previous section. However, if such articles played a part here they were not contaminated by plague-stricken persons, for our patients most often had no association whatever, direct or indirect, with the sick. The one suggestive common feature in their histories is their association with plague-stricken rats. Perusal of the accounts of the two epidemics that have occurred in this State shows that plague-rats have pre-eminently figured as the associates of plague in man, and in many localities it was clearly manifest that they were the forerunners of the incidence of the disease upon human beings. Our experience does not permit us to doubt that the rats were the sources of infection for our patients. But actual contact with them was exceptional; most usually the evidence went no further than to reveal the presence of plague-rats in the vicinity of the place where the patient became infected. As the implied intermediary between rats and human beings, suspicion might reasonably be attached to materials contaminated by the rats.

260. But given the lesion of the skin referred to in the previous section, and given contaminated material such as that just described, infection yet depends on the accidental conjunction of the two within a limited period of the time the last mentioned has received its load of bacilli from the rat. For this conjunction to occur with sufficient frequency to produce an epidemic of plague implies that the bacilli are distributed broadcast by the rats. But there is no good evidence that plague-rats do so generally infect their surroundings. On the other hand attention has already been called (Report 1900, p. 55) to the fact that rats, guinea-pigs, and mice were often placed by us in intimate contact with their artificially plague-infected fellows, or in the uncleaned cages and jars in which animals had died of plague, without in any single instance becoming infected. More recently we have exposed guinea-pigs with shaved abdomens in similar jars with the same negative results, even when the jar and its contents were additionally contaminated with culture material quickly fatal to inoculated controls. The escape of these very susceptible animals under conditions so favourable for mediate infection from soiled articles makes it difficult to conceive how the chance transference of the bacilli in this manner can be epidemiologically significant. In view of all the circumstances it would appear that whilst this mode of infection is possible, and may be occasionally operative, available evidence falls far short of indicating, or even suggesting, it to be the usual or regular means by which epidemics of plague are maintained.

261. That is a very lucid description of the circumstances which must obtain in order that the infection of plague may be communicated from the rat to man. There must be a breach of that epithelium whose function it is to defend the body against invasion by micro-organisms; the breach must be recent and (probably) not more than twenty-four hours old; the infection must be deposited by the rat on inanimate articles with which man can come into contact (or, rather, epidemiologically speaking, is likely to come into contact), and it must not, as a rule, be more than three or four days old: and then, when these four conditions have coincided a fifth must concur with them, which is, apposition of the wound and the deposited infection. The chances against the required conjunction are evidently many. Slight defects of the epithelium sufficient for the contemplated purpose are, perhaps, not very uncommon, and rats which traverse articles in use by man at the requisite stage of illness can discharge infection upon them (from the nasal mucous membrane in earlier, with the excreta at later, stages); yet it does not require much consideration to see that in practice the infection can rarely be taken thus. But I have already expressed an opinion that among the conditions necessary to the spread of infection from rat to man there must be some one (at all events) which is rarely present in conjunction with the rest; can failure to bring the minute wound into contact with the small quantity of deposited infection be it? Clearly such failure must happen much more often than not.

Twelve Cases in which Infection was not taken, in all Probability, by Casual Contact with Deposited Infection.

262. The infection of plague is communicated to man by inoculation through the skin in the vast majority of cases. The proof has been well stated in the Report of the Plague Commission in India; it is " . . . . that primary buboes practically always develop in connection with lymphatics which originate in the skin . . . . . " The constant preponderance of "inguinal" or "groin" buboes over others, was also shown in the same paper to stand in relation to the larger area of skin which drains through the lymphatic glands of the groin. Analysis of returns, which represented 5,442 cases of bubonic plague, showed that the ratio in which buboes occurred in the lymphatic glands of the head and neck, the axilla, and the groin respectively, was nearly the same as the ratio which the skin-areas draining through the lymphatics of those regions bear to each other.

263. The proportion in which groin buboes are met with always preponderates over that in which the buboes occur in other regions of the body; this was very early observed among Eastern races who habitually go barefoot. Before long, however, the same preponderance was noticed among Europeans (though in small number) who did not go barefoot; but the hint thus given seems to have been overlooked, and (perhaps, in consequence) assumed infectiveness of ground-surfaces became a prominent feature in writings on the ætiology of plague. But at Sydney, in 1900, we were able to show that in no less than 73 per cent. of the 286 cases in which buboes were exhibited, the latter were found in the groin, although all the patients referred to were white, clothed in European fashion, and invariably shod during the day (Report, 1900, p. 40). The validity of the banal explanation of the preponderance of groin buboes thus seemed to be rendered more than doubtful.

264. But I had pointed out in the same Report, that the infection of plague was received by man, for the most part, within houses; which seems also to have been noticed in India (Plague Commission in India, July, 1901, Report, p. 101). Now, if the infection be usually received by man within houses, the objection raised above to the banal explanation of the preponderance of groin buboes must be revised; for there is a time of day when nearly all people, whites as well as others, go barefoot; namely, when they are going to bed or rising from it. At that time, therefore, infectious material deposited on floors, carpets, &c., by rats (or otherwise) would be more likely to come in contact with the unprotected skin of the feet than with that of any other part of the body. So that, although conjunction between a recent breach of the epithelium and deposited infection in the requisite state of activity cannot often happen, here is the opportunity for it at all events; and plague was not so frequently contracted by our people in either epidemic but that possibly those persons who exhibited groin buboes might have received the infection in that way. Let us try, then, to ascertain what the fact was: Does the record contain any cases in which infection resulting in groin buboes was, probably, not contracted by casual contact with deposited infection of the unprotected skin of the lower extremities? If it turn out that it does, the hypothesis under examination will be very greatly weakened; must, indeed, be discarded as an explanation of epidemic bubonic plague.

265. Among the 139 cases which constituted the epidemic, there were 106 in which buboes occurred in the groin. But it is necessary to speak more exactly. Our present concern must be with primary buboes, since these alone indicate the region of skin through which the virus entered; and, in order to leave no room for possible confusion between primary buboes and secondary glandular swellings, it is desirable to take into account only those cases in which the groin bubo was solitary. Then the expression "groin bubo" is loose. A bubo in one of the oblique set of inguinal glands indicates infection through the skin of the lower part of the trunk. Buboes in one of the vertical set of femoral glands alone indicate infection through the skin of the feet, or of other part of the lower extremity. An examination intended to discover whether there were buboes betokening infection through the skin of the lower extremity must, therefore, be limited to cases which exhibited *solitary* buboes in one or other gland of the *femoral* chain.

266. The total number of such cases was 60, but the majority are not available for the present purpose. Thus the place at which the infection was taken could not be determined in 16 of them; either the inquiries made failed to reveal any clue to it, or else the evidence for infection at home and at work seemed equally cogent. These 16 must be thrown out, therefore, for they (or some of them) may have been infected at their place of residence, where they were admittedly exposed to the risk ascribed to bare feet which is now under investigation. In 25 other cases it was considered that the patient did receive the infection at his place of residence; so that these, too, must be thrown out for the reason just given. In 3 others the place of employment probably was the place of infection, but the details left room for some slight doubt; these are excluded by way of precaution. Three more were Chinese, concerning whom either information of the required kind could not be got at all, or it was untrustworthy. Lastly, one was a woman whose movements could not be traced. So that 48 of the 60 have to be discarded.

There

There remain 12 patients who had solitary femoral buboes, and who are confidently adjudged to have received the infection away from home (while at work, in all but one case) and therefore while fully clothed.

267. Most of these twelve cases have been already referred to at greater or less length; their serial numbers are therefore given, together with a reference to the paragraphs in which the necessary particulars concerning them may be found: 1 (par. 77), 14 (par. 92), 18 (par. 212), 211 (par. 21), 34 (par. 217), 49 (par. 134), 70 (par. 218), 84, 88, 93, 125, 129 (par. 219). The following are details of the four cases which have not previously been described:—

Case 84.—M., æt. 39, a tailor; attacked, March 26, at midday, while at work; discharged, May 24; place of employment, 267 Pitt-street. From under the floor of the room in which the patient worked as a presser nine carcases were removed; many others were found under the floors of adjacent rooms, as well as large quantities of rats' dung, nests, rags, paper, and seeds (from a florist's). Place of residence, Strathfield, a suburb 7 miles away, which has harboured no other case of plague at any time; the house was in very good order, and entirely free from all traces of rats.

Case 88.—M., æt. 55, carpenter; attacked, March 27, morning; discharged, April 26; place of employment, Union S.S. Co.'s wharf, Darling Harbour, which was one of the infected line. Residence, Leichhardt, a suburb about 3 miles away, which had yielded no indigenous cases; the house was in good order, clean, and entirely free from all traces of infestation.

Case 93.—F., æt. 27, sempstress; attacked, April 3; discharged, May 24; place of employment, an upholsterer's, 137 to 141 Castlereagh-street. There were abundant signs of infestation with rats everywhere, but no carcases were found; dead rats had been seen six weeks earlier when, it was alleged, poison had been laid. Residence, Marrickville, a suburb about 4 miles away, which had at no time harboured any other case; the house was in good order, and entirely free from all traces of infestation.

Case 125.—M., æt. 54, carman; attacked, May 11, midday; died, May 16; place of employment, Gray's stables, Elizabeth-street, Waterloo, which were infested with rats, and from which a plague rat had been taken on April 26; another plague rat was taken at other stables near by on April 21. Residence, 151 Bullanaming-street, in fair order; it was said that no rats had been seen there, and there were no traces of infestation; no indigenous case had occurred anywhere near the house, but the further neighbourhood of it was not free from suspicion.

268. Of these patients 8 inhabited houses in neighbourhoods which were distant or even remote from the infected area, and which were at all times free from suspicion of infection with plague (yielded neither indigenous cases, nor plague-rats); and while, on the one hand, 11 of the residences bore no traces whatever of infestation with rats (the twelfth alone having exhibited some slight signs of infestation), on the other hand the places at which the patients were employed (including one who had merely visited Her Majesty's Theatre) were badly infested, and had yielded dead rats in number in ten instances at least.

269. It is certain that these persons all fell into danger at their place of employment, and apparent that they were not infected at home. At their employment they were fully clothed; their lower extremities were protected by boots, socks, or stockings, and trousers or petticoats, while their hands, arms, necks, faces, and in some cases their chests too, no doubt, were uncovered, exposed, and in no way protected from casual contact with deposited infection: and, therefore, they should, *ex hypothesi*, have exhibited cervical or axillary buboes. In fact, however, they none of them did so. They were all of them inoculated in one or other lower extremity—in that very area of skin which, beyond all doubt, was well protected from casual contact with deposited infection.

270. I am unable to imagine any plausible explanation of the inoculation of these 12 persons in the lower extremity, which does not include some means of communication between them and plague-rats which is complete in itself, endowed with locomotive powers, attracted to man by instinct, and more likely to reach this than any other part of the body. These requirements betoken an insect, and the insect which best meets them appears to me to be the flea.

Only one other mode of common communication of the infection from rat to man can be surmised, namely, soiling of food with infective excretions or secretions. But the conclusion that bubonic plague is taken by inoculation through the skin is generally accepted on definite pathological evidence; while the other generally-accepted opinion that, at most, man has very rarely been infected by feeding, is based on the all but entire absence of similar pathological evidence to the contrary.

271. Simond's results with fleas have not as yet been corroborated in this laboratory; but several unsuccessful attempts have shown that the experiment is a very difficult one to control, rather than that the infection cannot be conveyed by means

means of fleas. A good deal of time has been devoted to preliminary or collateral points by Dr. Tidswell, whose results and remarks upon them are embodied in the following report :—

Ecto-parasites of the Rat. By Frank Tidswell, M.B., Ch.M., D.P.H., Micro-Biologist to the Board of Health.

(c) *The Ecto-Parasites of Rats.*

272. The failure of available facts to clearly incriminate deposited infection as the source of plague in our patients made it important to investigate another possible intermediary. In the previous report (1900, p. 56), attention was called to Simond's suggestion that the fleas from rats probably played such a part. In connection therewith it was mentioned that the phlyctenules described by Simond as resulting from the bites of plague fleas had been observed in a few cases in which they had been looked for; that plague bacilli had been found in one of them, and had been also obtained from fleas taken from an infected rat (loc. cit. Appendix A, p. 56). During our more recent experience the occurrence of plague bacilli in fleas taken from infected rats has been twice more demonstrated in a similar way, viz., by cultivation and inoculation experiments. This thrice-repeated observation is in accord with the accounts of other investigations elsewhere, and it seems now well established that fleas from plague rats can harbour plague bacilli. Although this is so, it has not yet been adequately demonstrated that the bacilli so harboured can be carried over to other animals to which the affected fleas have access. Simond, indeed, reported successful results, but the similar experiments of Dr. Kolle in Berlin (Zeit. f. Hyg. Bd. 36, s. 412), and those performed in this laboratory (Report, 1900, p. 57) had negative issues. From the experimental point of view, Simond's observation remains hitherto unconfirmed.

273. Objection to the theory has also been made in view of the nature and species of fleas infesting rats. Simond, whilst candidly admitting his inability to pronounce upon the species of the fleas found by him upon rats in India, and to which he attributes the power of transmitting plague, nevertheless distinctly states that the fleas in question did bite human beings on whom they were placed. (Annales de l'Institut Pasteur XII, p. 673.) On the other hand it has been contended that the fleas infesting rats will not bite man. Dr. Nuttall, of Cambridge, points out that the "rat flea"—*Typhlopsylla musculi*—belongs to an entirely different family from the flea of man—*Pulex irritans*—and that there is no evidence that it will use man as a host (Johns Hopkins Hospital Reports, VIII, p. 21; Jl. Trop. Med., V, p. 65), whilst Professor Galli Valerio, of Lausanne, reports similarly with respect to the two species of fleas—*Typhlopsylla musculi* and *Pulex fasciatus*—found by him upon rats in Europe (Cent. f. Bact., XXVII, s. 1; *ibid.*, XXVIII, s. 842; Jl. Trop. Med., V., p. 33). Briefly, it is said on the one hand (Simond) that fleas from rats did bite man, and on the other hand (Galli Valerio), that fleas from rats did not bite man. In view of the simple nature of the fact to be determined, it would appear most likely that the discrepancy is due to the reference being to different species of fleas. For it by no means follows that the rats in India and in Europe are exclusively infested by the same species. Available accounts, indeed, clearly indicate that a species prevalent at a particular place or time may be represented by a different species at another place or time. For instance, Mr. Carl Baker expresses the opinion that *Pulex inaequalis* seems to be the North American representative of *Pulex goniocephalus* of European hares and rabbits (Canadian Entomologist, XXVII, p. 164), and Mr. L. O. Howard reports that the species which commonly overruns houses during damp summers in the Eastern cities of America "is not, as many have supposed, the human flea,—*Pulex irritans*—but the common cosmopolitan flea of the dog and cat"—*Pulex serraticeps*—(Bulletin No. 4, Division of Entomology, U.S. Department of Agriculture, 1896, p. 24). Further, it is mentioned in the report of the outbreak of plague at Sydney, 1900 (p. 40), that *Pulex serraticeps*, a species known to attack man, was found upon the rats examined during that epidemic. This last occurrence is not noted in any other document available to me, and Professor Galli Valerio's comment upon it is that it must be so rare as to be accidental. However this may be, it is clear from the items just quoted that there is need for inquiry as to whether the prevalent species in Europe are also the prevalent species elsewhere. For unless this be shown to be the case statements concerning the habits of *Typhlopsylla musculi* and *Pulex faciatus* are insufficient to negative the idea of the participation of a flea of some kind in the dissemination of plague.

274. In pursuing our investigation of Simond's theory it seemed desirable, in view of what has been said above, to ascertain in the first place the exact species of fleas to be found upon our rats. The opportunity afforded by the receipt of rats for the pathological and bacteriological examinations already described was accordingly made use of to secure specimens of fleas upon them. It usually happened that the carcases of the rats were brought to us wrapped up in paper parcels. To facilitate collection of the fleas, as well as a precautionary measure of protection against possible danger from them, it was made a rule to pour a little chloroform through a small hole in the paper before the parcel was opened. This sufficed to stupefy or kill the fleas, which were then picked up from the paper or obtained from the fur by searching with the aid of a fine-toothed comb. This process was carried out during the height of the epidemic until about 100 specimens were collected; this number being deemed adequate to afford a reliable representation of the species present. The fleas obtained were immediately placed in Xylol and afterwards mounted in Canada balsam for microscopical examination. In classifying the species I have been mainly guided by Mr. Carl Baker's descriptive list (Canadian Entomologist, V. 27), but access was also had to Taschenberg's "Die Flohe," to Neumann's "Traité des Maladies Parasitaires," and to other works of a similar character. I have also to gratefully acknowledge assistance afforded to me by Professor W. A. Haswell, F.R.S., Sydney University, and by Mr. W. G. Rainbow, F.L.S., Entomologist to the Australian Museum, Sydney, who were good enough to examine my specimens and check my determination of species.

275. The initial position of affairs, so far as one could gather it from available documents, was that one might expect to find on the rats two species of fleas—*Typhlopsylla musculi* and *Pulex fasciatus*—and there was a suggestion that at least one other species—*Pulex serraticeps*—might also be found upon them. Actual examination of the specimens collected as above described showed, however, that no less than four species were represented. In accordance with the statements of European and American observers two of the species were *Typhlopsylla musculi* and *Pulex fasciatus*. In confirmation of our previous report

report the third species was *Pulex serraticeps*. But the fourth species was one not hitherto mentioned as occurring on ordinary rats. A photograph of this flea (as well as of the other species found) is given in the plates herewith. After long and minute examination I concluded the flea was *Pulex pallidus*, or else was an undescribed very close ally of that species. In this conclusion Mr. Rainbow agrees, as also does Professor Haswell, although the latter points out some minor differences from Mr. Baker's description of the type. I have, therefore, felt justified in referring to the flea as *Pulex pallidus*, at all events provisionally and for the purposes of this report. Mr. Baker states that *Pulex pallidus* has been found on *Mus albipes* (the Abyssinian white-footed rat) in the island of Socotra, and upon *Herpestes ichneumon* (Pharoah's rat) in Egypt, so that its being found here upon a species of rats would be consonant with its already known habits. It is more particularly interesting in being a very near relative of the flea of man—*Pulex irritans*—from which it differs in general size and colour it is true, but otherwise only in details such as the comparative lengths of the tarsal joints, number of joints in labial palpi, and conformation of male generative organs.

276. The species referred to, and henceforward in this report called *Pulex pallidus*, not only occurred on the rats, but was by far the most abundent species present. Of the 100 specimens collected and examined as above-mentioned, 10 were identified as *Pulex fasciatus*, 8 as *Typhlopsylla musculi*, 1 as *Pulex serraticeps*, and no less than 81 as *Pulex pallidus*. The overwhelming percentage of the last-named species removes its occurrence from the sphere of accident; there can be no question that at the time the observations were made it was the prevailing species of flea infesting the rats.

277. In order to determine whether this occurrence of *Pulex pallidus* was a purely local circumstance, or applied also to other parts of Australasia, I addressed a request for specimens to official confreres in the other States of the Commonwealth and New Zealand. I have here to thank Dr. Burnett Ham, of Queensland; Dr. Astley Gresswell, of Victoria; Dr. T. Borthwick, of South Australia; Dr. Blackburne, of West Australia; and Dr. Mason, of New Zealand, for their generous efforts in response. I append hereto a tabular statement of the species found amongst the specimens so kindly forwarded, except as regards those from Victoria which arrived in too mummified a condition for accurate observation. By way of completion I have inserted the figures for Sydney, and those for the fleas forwarded from Newcastle in this State by my colleague, the Medical Officer of Health of the district, Dr. Robert Dick.

TABLE XXVIII.—Showing Numbers and Species of Fleas obtained from different parts of Australasia.

Locality.	No. of Specimens.	*Typhlopsylla Musculi.*	*Pulex Fasciatus.*	*Pulex Serraticeps.*	*Pulex Pallidus.*
Brisbane, Queensland	103	18	.....	6	79
Adelaide, South Australia	1	.....	.....	.....	.....
Perth, Western Australia...	6	5	.....	.....	1
New Zealand	56	3	53	.....	.....
Newcastle, New South Wales	34	24	3	.....	7
Sydney, ,, ...	100	8	10	1	81
Totals	300	58	66	7	169

278. It will be seen from the table that *Pulex pallidus* was found amongst the specimens from every place except New Zealand. The fact of its presence in Brisbane, Newcastle, Sydney, Adelaide, and Perth, justifies the inference of its general distribution along the east, south, and west coasts of Australia, for it is probably to be found also in Melbourne. As no response was made to my letter to Tasmania, I have no data with respect to that island.

279. *Pulex fasciatus* comes next in point of numbers, but was found in three only of the places mentioned.

280. Specimens of *Typhlopsylla musculi* were nearly as numerous as *Pulex fasciatus*, and were more generally distributed, being actually present in all but one, and probably to be found in all the places mentioned.

281. Least numerous were specimens of *Pulex serraticeps*, which were found only amongst those collected at Sydney and Brisbane. It may be mentioned, however, that some of the dried fleas forwarded from Melbourne appeared to belong to this species.

282. It will be seen from these observations that the ordinary fleas of rats—*Typhlopsylla musculi* and *Pulex fasciatus*—noted by European and American authorities, are well represented upon the rats in this part of the world; that another species, here called *Pulex pallidus*, and not noted by the authorities mentioned, is even more common upon the rats of the Australian continent, and that *Pulex serraticeps* is to be found upon our rats in some instances. Whether or not the number of the latter is so small as to be validly attributable to accident may be left an open question. It is at least certain that *Typhlopsylla musculi* and *Pulex fasciatus* are not the only species of fleas to be found upon rats; consequently inferences based upon observation of them alone cannot be accepted as valid evidence in refutation of Simond's suggestion.

283. By way of corollary to the examination of fleas from rats a similar collection was made of fleas from man. Of 101 specimens thus obtained, 85 were *Pulex irritans* and 16 were *Pulex serraticeps*. It may here be added that a single flea obtained from a wallaby during the prevalence of plague at the Zoological Gardens was a *Pulex serraticeps*, and that numerous specimens obtained from dogs and cats all belonged to this species.

284. As regards the capability of attacking human beings, we have but few observations to report. It happened that whereas during the prevalence of plague, we had no particular difficulty in collecting the 100 specimens mentioned above, yet since the disappearance of the epizootic the rats examined have

have been remarkably free from fleas. Our frequent searches for specimens have been most usually fruitless. It was only now and then that we came across two or three fleas on some particular rat. These rare specimens were either *Typhlopsylla musculi*, *Pulex fasciatus*, or *Pulex pallidus*. Our observations upon their ability to bite us were made during this period of scarcity, so that we were not able to make extensive trials. Our experience as far as it has gone is in accord with the statement that *Typhlopsylla musculi* will not bite man, but we have been bitten by all three pulices. A specimen of *Pulex fasciatus* which bit one of my assistants was afterwards seen by microscopical examination to have its stomach full of fresh (bright red) blood. In some trials with specimens of *pallidus* immediately after they were taken from rats the parasites refused to bite, but a flea of this species bit me readily enough after being kept without food in a glass phial for about four hours. The sensation of the bite, the subsequent wheal, and the presence of bright red blood in the stomach furnished convincing evidence of the parasite's attack upon me. This experience was subsequently repeated upon other persons with like result. As to *Pulex serraticeps*, authorities are agreed that it will bite man, and this is also vouched for by common experience of fleas from dogs and cats.

It will be seen that although we cannot claim to be in a position to make any general statement with respect to the proclivities of the various fleas, the few trials we have made show clearly enough that of the four species found by us upon rats, three—*Pulex pallidus*, *Pulex fasciatus*, and *Pulex serraticeps*—possess the ability to bite human beings. The fact that they could do so as a matter of laboratory observation does not necessarily imply that they would also attack men under more natural conditions; but this does not seem to be an unlikely event, especially if the circumstances be such as to deprive the fleas of ready access to their accustomed pabulum, as must be considered to happen at times in the course of an epizoötic of plague. Upon more than one occasion the officers of this Department in charge of cleansing gangs have reported that the men have been invaded by hordes of fleas when dealing with places at which rats had recently died in large numbers. On two occasions we had the opportunity of verifying the fact that men had been abundantly bitten by fleas, but we did not succeed in obtaining specimens from the men nor from the places concerned. Hence we cannot pronounce as to the species of fleas responsible. In view of the fact that *Pulex pallidus* was the only species occurring abundantly on the rats it naturally falls under suspicion; but there is no certainty that the invading fleas came from the rats, for it is to be remembered that *Pulex irritans* sometimes swarms about habitations. It might be expected that if such fleas came from the rats and could carry plague bacilli with them, the fact would be indicated by some incidence of the disease upon members of the cleansing gangs. It actually happened that six of these men, as well as two rat-catchers associated with them, in all eight persons, became infected with plague. Consequently, although we cannot definitely assert that the fleas commonly infesting rats will of their own accord attack man, there are no data within our knowledge opposed to this eventuality.

The foregoing statements suffice to show that one species of flea—*Pulex serraticeps*—exhibits considerable catholicity in the matter of a host. Mr. Baker mentions various animals upon which it has been found (loc. cit., p. 164), and we have here taken it from cats, dogs, rats, human beings, and a wallaby. In view of the fact that it occurs on both rats and man, it would not be unreasonable to infer that to it, if to any flea, might be attached the suspicion of disseminating plague in accordance with Simond's theory. In this connection it is interesting to note that in Simond's successful transference experiment the fleas concerned are said to have been obtained from a cat. Presumably they or some of them were *serraticeps*. However, two experiments after Simond's plan made in this laboratory with the object of ascertaining if this particular species could act as a carrier of plague from rat to rat yielded negative results.

In the three instances in which plague bacilli were found by us in fleas from plague-stricken rats the species of flea concerned was always *Pulex pallidus*. We are not in a position to state whether or not the bacilli occur in other species of fleas, since we made no systematic observations to determine this point. The circumstance that they were found in *pallidus*, combined with the fact that this species was so abundantly present upon the rats during the epizoötic, brings this flea also under suspicion as a possible transmitter of plague. Although, as already stated, it was ascertained to bite man when hungry, no representatives of the species were found amongst the carefully-searched collection of fleas from human beings. This collection was indeed made after the disappearance of plague from this city—at a period when the rats themselves were almost entirely free from fleas, and so is scarcely adequate to conclusively determine the occurrence or non-occurrence of *pallidus* on man in relation to the question under review. We have been unable to perform any transmission experiments with *Pulex pallidus*. As already stated, the supply of them unexpectedly ran short just at the time when the pressure of work occasioned by the epidemic began to relax sufficiently to enable us to undertake experimental researches. Under the circumstances this flea remains for us merely an object of suspicion to be further investigated if the opportunity presents itself.

With respect to the two remaining species—*Typhlopsylla musculi* and *Pulex fasciatus*—there is nothing to add to what has been said above. For the reason already given, we have not been able to collect them in sufficient numbers for experiment.

The two experiments with *Pulex serraticeps* mentioned above, as well as the two others recorded in the previous report (1900, p. 57), all failed to secure the transmission of plague from infected to healthy rats by means of living fleas. The method we adopted was as follows:—A rat was placed in each of two small wire cages, which were in turn enclosed, with about 4 inches of space between them, within a galvanized iron box. One of the two rats was inoculated subcutaneously with bacilli pestis, and in the course of a day or so, when the animal became sick, a number of fleas was placed upon it. Always the inoculated rat died in the usual time, presented the usual *post-mortem* appearances, and was proved to have died of plague by the usual bacteriological procedures. But always also the companion uninoculated rat remained free from plague. In two instances this survival was shown not to be due to immunity since the rats concerned subsequently succumbed to inoculation with bacilli *pestis*. In the other two instances the companion rats died in one and three days after their respective inoculated associates, but their deaths were not due to plague. The *post-mortem* appearances were not those of plague, nor were bacilli *pestis* seen in smear preparations or obtained in cultures from the blood and viscera. In one of them the blood was teeming with *Trypanosoma*, but beyond this there were no definite indications of the cause of death in either case. It has been our experience that the particular

particular species of rat (*Mus decumanus*) made use of does not generally survive long in captivity. Thus, although two of the rats died in a suggestive manner, it could not be ascertained that they died from plague.

290. The method just described was initially adopted as approximating to that by which Simond obtained success; but a close scrutiny of details reveals it as one very apt to miscarry. For example, in the two experiments more recently performed, the inoculated rats received respectively ten and six specimens of *Pulex serraticeps* obtained from a dog. These fleas promptly disappeared in the fur of the rats, and there our cognisance of them ended. For after death the carcase of the first rat furnished no fleas, and that of the second gave us two specimens of *Pulex fasciatus*. Both carcases had been left untouched for twenty-four hours after death. The carcases of the companion rats being duly searched immediately after their deaths in twenty-four hours and three days respectively after their inoculated associates, yielded, the one a single specimen of *Pulex serraticeps*, and the other, no fleas at all. In the cages we found three specimens of *Pulex pallidus*. After the experiment then we collected 6 fleas, 2 *fasciatus*, 1 *serraticeps*, and 2 *pallidus*—none of which harboured bacilli *pestis*; for smear preparations and cultures from them were all negative. It may be that the single *serraticeps* was one of the sixteen previously placed on the inoculated rats, but this is not certain, and in any case the fate of the other fifteen is not accounted for. It is evident that the method afforded no guarantee that the fleas used actually passed from rat to rat. Some further observations were made by a more hopeful process, kindly suggested to me by Dr. J. S. C. Elkington as having been successfully applied in India by himself and Captain Liston, I.M.S. In this the fleas were retained in test tubes, covered with muslin or chiffon, through which they could bite but not escape. On three occasions fleas were allowed in this way to bite guinea-pigs, sick after inoculation with plague cultures, and, subsequently, to bite other healthy guinea-pigs. The three inoculated guinea-pigs died in the usual time, and presented the usual *post-mortem* appearances of plague, their viscera yielding bacilli *pestis* in abundance. The five associated guinea-pigs also died in periods varying from two to eight days after being bitten by the fleas, but it could not be demonstrated that their deaths were due to plague. In only one instance were the *post-mortem* appearances suggestive of this disease, and from this case a bacillus was isolated, which had, at first sight, considerable resemblance to bacillus *pestis*, but by subsequent investigation was proved not to be that micro-organism. In three of the other animals micrococci only were isolated, and in the remaining one the smear preparations and cultures were all negative. It has to be noted that cultures of blood, taken from the inoculated animals at the time they were bitten by the fleas, yielded bacilli *pestis* in only one of the three, so that there was room for failure in the other two cases. The significant fact of the death of these five animals is not, to my mind, adequately accounted for by the results obtained, and I purpose entering in the near future upon some further experiments with this method. In the meantime, I infer that, although the results obtained by us with respect to the experimental transmission of plague by fleas have as yet been negative, they are properly to be regarded only as inconclusive.

291. Making due allowance for the considerations just presented it will be apparent that whilst the observations made in this laboratory do not furnish convincing proof of the participation of a flea in the dissemination of plague, they are nevertheless all consistent with that hypothesis. We have found that rats coming under our notice during the prevalence of plague harboured more fleas than did those examined after the subsidence of the epizoötic. The fleas collected from them represented four species, of which one—*Pulex serraticeps*—is known to attack man, whilst two others—*Pulex pallidus* and *Pulex fasciatus*—have been ascertained to be capable of doing so. Specimens of one of these species—*Pulex pallidus*—have been three times found to harbour plague bacilli, which produced plague in animals, into which they were inoculated, and were, therefore, virulent. We have also (v. Report 1900, p. 56) found plague bacilli in a phlyctenule, such as has been said to be produced by the bites of infected fleas. Against these various items of positive evidence we have opposed only the results of the transmission experiments which we may not yet consider of final import.

292. It may here be mentioned that the rats were found to be richly infested with bugs. These were in various stages of development, but comparatively few of them were adults. Reference to the authorities of the Australian Museum elicited the information that the species was *Cimex lectuaris*. These parasites continued to occur on the rats after the subsidence of the epizoötic, and are now apparently as numerous as ever. No experimental observations have yet been made with them.

293. A preliminary objection to the hypothesis that plague might be conveyed to man by fleas which had previously bitten rats infected with the disease, has been raised by Nuttall, and by Galli-Valerio; it is, that "rat-fleas" do not bite man. The species of fleas thus referred to by those writers were *Typhlopsylla musculi* and *P. fasciatus*; and these appear to be the species which most commonly infest rats, in some parts of Europe, at all events. The observations now recorded by Dr. Tidswell expose the crudity of this criticism. In the first place, as to the species of fleas which infest rats, he found that, although he was able to collect both *Typhlopsylla musculi* and *P. fasciatus* (Baker), another species, namely, *P. pallidus*, was far commoner on the rats of the Australian coast-line. Here, it may be noted, that Dr. Tidswell first indicated *P. pallidus* as a species commonly infesting rats, an observation which was found to hold good of the rats at Bombay after he had communicated it to correspondents in that city. But, further, the concluding sentence of the abstract paper by MM. Raymond and Gauthier, which is inserted in translation below, furnishes some reason for supposing that the same species might be found on rats in some parts of Europe. And then, secondly, as regards the capacity of the species collected to bite man, Dr. Tidswell tells us that both *P. pallidus* and *P. fasciatus* have done so repeatedly at his hands; it further appears

that

(a)

(b)

(c)

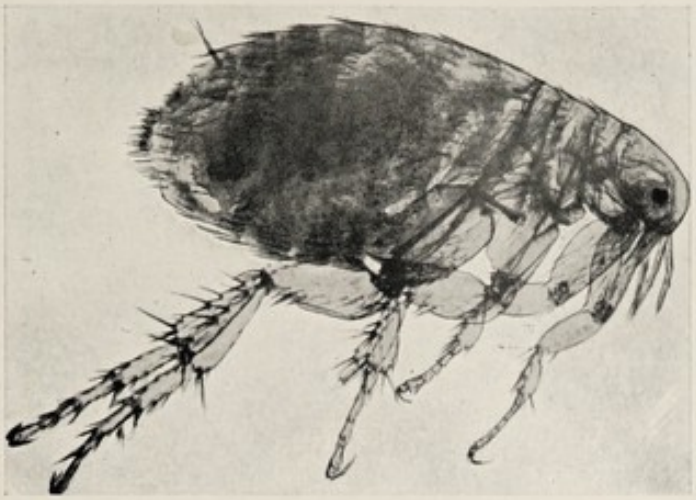
× 250

Frank Tidswell.

PHOTOMICROGRAPHS OF FLEAS.

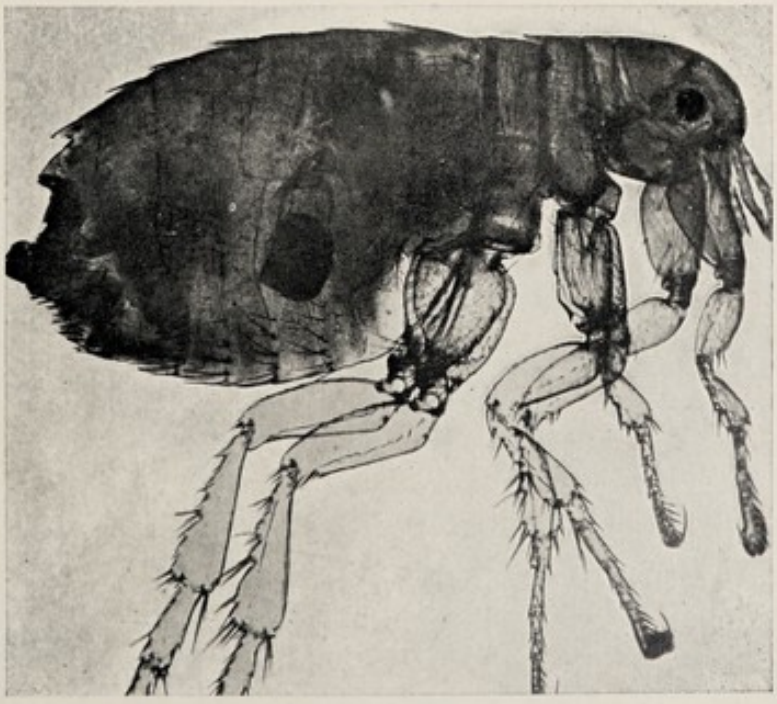
(a) PULEX FASCIATUS, FROM RAT. (b) TYPHLOPSYLLA MUSCULI, FROM RAT.
(c) PULEX SERRATICEPS, FROM RAT.

(d)



(e)

(f)



x⁰ 250

Frank Tidswell.

PHOTOMICROGRAPHS OF FLEAS.

(d) PULEX PALLIDUS, F., FROM RAT. (e) FULEX PALLIDUS, M., FROM RAT.

(f) PULEX IRRITANS, FROM MAN.

that the condition which determined them to bite man was nothing more recondite than hunger. MM. Raymond and Gauthier also found that *P. fasciatus* and *P. pallidus* would bite man. It must, therefore, be considered that the preliminary objection raised by Nuttall, and by Galli-Valerio, has been met; "rat-fleas"—to use the loose phrase employed by those writers for the last time—will bite man. It is probable that *P. pallidus* and *P. fasciatus* do not infest man, and it may be conceded that they do not very eagerly feed on him; the rat, no doubt, is their host of election, although it is plain that they have no repugnance to man. And it appears to me that the phenomena of epidemic plague, as observed at Sydney, require that the intermediary between rat and man should be more usually restrained from acting as such, than encouraged by its instincts to do so. However that may be (for the reader will doubtless reflect that there are other conditions which may act in the same direction of restraint, though by other means) we have here one possible reason why the vicinity of plague-rats is more often harmless to man than it is a cause of plague in him.

294. A further objection has been also raised by Nuttall; it was based on the rapidity with which the bacilli of several diseases, among which plague was not included, lost their virulence after entering the stomach of the flea; this was the result of a long series of experiments performed by him, in which he caused fleas to bite animals previously infected with anthrax, chicken-cholera, and some other diseases. His argument, it will be observed, was from analogy; it now seems to have been met by direct observation. In the first place, MM. Raymond and Gauthier, working at Marseilles, performed many experiments in the transmission of plague from animal to animal, by means of fleas, during the latter half of 1902, and, in December of that year, published the following note, which, on account of its great interest, I take the liberty of translating below:—

"We have undertaken some researches with a view to test Simond's theory of the share taken by the parasites of the rat in the spread of plague.

"In five experiments we have succeeded in transmitting the plague-septicæmia of an inoculated animal to a healthy animal by placing on the former fleas gathered on shore or ship-rats, and by afterwards exposing the healthy animal to the bites of the insects which had been thus infected.

"On the other hand, we did not succeed in effecting a similar transmission by means of the little acari which rats very often carry, nor by the simple cohabitation of healthy with infected animals.

"We then enquired whether the rat-flea would bite man: 14 insects out of 16 bit at once when they were placed on the human skin after having been kept fasting for twenty-four hours. A few fleas survived for many weeks, having been fed exclusively on man.

"Among the rat-fleas which bit man we were able to examine and determine 8; of these 7 were *P. fasciatus*, the kind most commonly found on rats, while the eighth was a kind of flea which had no comb, very like *P. irritans*, but smaller and paler."*

At a later date the authors published their paper *in extenso*.† From the latter it appears that they placed an infected rat in one compartment of a wire cage, and supplied fleas, collected from ship and from shore rats, to it shortly before its death. They then introduced a clean rat into the other compartment, which was separated from the first by an interval protected by a double grating, which was fine enough to prevent the passage of anything slightly larger than a flea, the interval between the two gratings having been about 2 cm. The whole was enclosed in a ventilated glass vessel, specially constructed so as to allow of access to the interior at the same time that the fleas were securely confined to it. It has been shown, again and again, that plague is not communicated from animal to animal when the healthy are put into cages which contain the body of a rat dead of plague, or when the healthy are placed in cages in which plague-rats have died, so that it may be taken that unless the disease was conveyed by the fleas, the healthy rats would have remained uninfected; but although, in addition, the compartments were so separated that the clean rat could not have reached the body of its previously-deceased companion, the result of these experiments was, it will be noticed, inferential as regards the mode in which the clean rat received its infection. This objection, which had been raised against the successful, though meagre, experiments devised and reported originally by Simond, which were arranged somewhat similarly, has been obviated in the method followed by Dr. J. S. C. Elkington, at Bombay,‡ working under Haffkine in the Plague Research Laboratory. The infected and the clean animals were never within reach

* Comptes Rendues de la Société de Biologie, LIV, p. 1,497, December, 1902.
† *Revue d'Hygiène*, XXV, p. 426, May, 1903.
‡ *Australasian Medical Gazette*, XXII, p. 348.

reach of each other. All communication between them, both direct and indirect, was prevented, except that which was the subject of investigation. The fleas were under control, and were placed, first on the infected, then on the clean animal. The clean animals are reported to have died of plague, which can only have been communicated to them by the fleas.

295. We have now reached the end of this study of epidemic plague. The conclusions to which it points differ fundamentally from those which are supported in the most recent writings on the aetiology of this disease. No attempt has been made to explain the discrepancies thus brought to light. I have described what we have seen. It is possible that different circumstances, obtaining in other parts of the world, may account for them in some minor respects; such are the comparative magnitude of epidemics, and their longer continuance elsewhere often witnessed. But as regards more general and (aetiologically) more important features, it is difficult to show that they have been modified by circumstances; unless, indeed, the larger proportion of persons dying at home (who, therefore, had bacilli in the peripheral circulation while they were still exposed to the bites of parasites) may have had some influence. On the other hand, the opportunity of making accurate epidemiological observations has often been denied elsewhere by the character and density of the populations among which epidemics have, for the most part, hitherto occurred. For this reason I am inclined to lay stress on our records; and when, after experience of two separate outbreaks, I am able to say that, with us, the disease was in no degree assisted to assume the epidemic form by direct or indirect communication with the sick, and that place-infection, in the Indian sense, did not exist, it becomes probable that the leading part invariably assigned to these factors by writers who have either worked under the unfavourable conditions adverted to, or who have had no practical experience with epidemic plague, as the case may be, requires revision.

296. As for ourselves, we were manifestly compelled to search elsewhere for a competent cause of the epidemics we had witnessed. We first looked for a source of the infection; we were able to find it, and even to surmise its presence, only in the bodies of diseased rats. We then examined into the distribution of cases in relation to the distribution of plague-rats, and we found that there was a singularly close correspondence between the two, both in time and in place. We noticed, again and again, the establishment of new centres of infection at distant and widely separated points, to which fodder had been transported from a line of wharves already known to be infested with plague-rats; and we remarked precedence of the disease in rats over its occurrence in man at those localised centres. But we also observed that on attempting to ascertain a more direct and closer connection between individual cases of plague and presence of plague-rats on the premises which yielded them, we succeeded only rather more often than we failed; although we learned at the same time that the considerable proportion of failures was merely incidental, in all probability, to the search conditions.

297. Nevertheless we met with many individual cases which seemed to throw great doubt on the efficiency of plague-rats as the cause of epidemic plague. We perceived that although neighbourhood of the latter seemed to be necessary to infection of man, contact with them was certainly not necessary; and, which is even more striking, we learned on irrefragible evidence that presence of plague-rats in a building was very often not accompanied by plague in any of the persons who inhabited it. Further, we found that when the presence of plague (or of dead) rats was accompanied by plague in man, by far the most commonly one person alone out of several composing the household was attacked. On the other hand, we often saw several cases arise at the same time among parties of people between whom the sole bond was daily resort to the same places of employment; and while those places of employment were ascertained to have harboured plague-rats, or at all events rats which had died of some epizoötic disease at a time when plague was known to be prevalent among their congeners in the immediate neighbourhood, it was also ascertained that the infected individuals among those who composed the several groups had, each of them, their dwellings in different houses, situated in widely separated neighbourhoods: which dwellings and neighbourhoods furnished no evidence of presence of the infection.

298. These observations, correct as they had been shown to be by repetition, were puzzling in as far as apparent absence of the only recognisable source of the infection did not betoken safety from plague, and in as far as its ascertained presence

was

was far from being invariably, or even commonly, attended with plague. In this doubt the pathology of the disease came to be reconsidered, in hope that it might furnish some hint pointing to a rational explanation of these apparent contradictions. We recognised the obvious possibility, little likely to be detected by common observation if it were realised, that food might be soiled by passing plague-rats, arrived, perhaps, from premises which they infested, at premises which showed no signs of infestation, but yet yielded cases of plague in man. But this hypothesis it was necessary to dismiss, because there is practically no pathological evidence that man is infected by feeding. If he can be thus infected, it is certain that he is so very rarely indeed; and in that way epidemic plague cannot be explained. On the other hand, the pathological evidence that man is usually infected by inoculation is abundant, uniform, and direct. We considered, then, whether man might commonly become infected by casual contact with virus deposited by plague-rats; for we know that it can be thus deposited, and is likely to be dropped in situations where it may afterwards come into contact with his skin. Thereupon we reflected that a function of the epithelium is to prevent the entrance of infections to the body by way of the skin, and perceived that if this mode is to take effect it can do so only when deposited infection is brought into apposition with a broken epithelium. This, it may be assumed, sometimes has happened; but what is being sought is not an exceptional mode of infection, but one which takes effect so commonly that it may be accepted as a cause of epidemic plague. When, therefore, the very short time is remembered during which such small wounds remain open as alone are in question (because the finding of wounds which might have served as points of entry for the virus in cases of bubonic plague was, in our experience, quite unusual); when the comparatively short, though much longer time, during which the virus survives in potentially active form, even under the carefully guarded conditions of a laboratory experiment is considered—a time which probably must be abridged under the conditions of daily life; and when it is noticed how small must be the parts of the ground-surfaces, &c., which can be thus infected, and, consequently, how great are the chances against the minute wound being brought into contact with them within the requisite times, it becomes apparent that the casual inoculation of man in that way is very unlikely to happen often enough to account for epidemics of plague. It is evident that the means by which he is inoculated must operate more directly and certainly than that. The riddle being still unread, we turned again to our epidemiological notes, and re-examined them. We found, without any difficulty, at least twelve out of the 139 cases in which inoculation could not have resulted from casual contact with deposited infection. They showed that in all probability it must have been effected by some agent, to which neither an unbroken epithelium nor protective clothes offered any important obstacle. But obstacles to chance inoculation both of them certainly are. We were unavoidably compelled, therefore, to contemplate an agent of inoculation possessed of means of evading or of overcoming them. In order to evade protective clothes this agent must be endowed with locomotive powers, and it must be capable of penetrating the epithelium without causing either noticeable pain or a visible wound. It is perceived, of course, that the flea best answers to these requirements.

299. As soon as this has been recognised, it also appears that the original hypothesis of the flea, taken in conjunction with recent observations on the habits of this insect, is exactly what is required to reconcile the apparent contradictions described above; to explain, not merely the erratic incidence of plague, but also the absence of any great probability of the infection being received by man from plague-rats when they are present on inhabited or frequented premises. For we know that the flea which most commonly infests the human race is of one species, while the fleas which infest other sorts of animals are different from it and (as regards several species) from each other; whence it seems evident, *a priori*, that species so usually associated with this or that sort of animal as to be found with certainty upon it when they are searched for, probably have a predilection for their peculiar hosts. On putting this probability to the test of experience, it is found to be so far well-founded that the species of fleas which infest rats seem, on the one hand, not to infest man, but, on the other, to have no repugnance to him. They will feed freely upon his blood if they be hungry. Hence it is plain that there are at least two chances against man's being bitten by any of the species which infest rats. One is that fleas which have left a plague-rat may never come within reach

reach of man though on the same premises with him; the other is that, if they reach him, they may do so at a time when they are not so urged by hunger as to bite an unaccustomed host. These chances amply suffice to account for the frequency with which all the persons who inhabit premises which are known to have been visited by plague-rats escape, as well as for the rarity with which more than one person is attacked among a household which consists of many, all of whom are susceptible, and all of whom appear—but only appear—to have been equally exposed to danger.

300. Thus, I have been led to conclude that Simond's hypothesis of the flea best explains the phenomena of epidemic plague as seen at Sydney; not, be it noted, by considerations based on his original assertion that plague could be communicated from animal to animal by fleas, but *a posteriori*—that is to say, by observation of the field-facts, as they may be called, and by inference from the records made day by day after they had been collated and duly weighed. And here I would point out a matter which has been overlooked by those who have unreservedly accepted the hypothesis of the flea before it had been sufficiently tested either in the field or in the laboratory. It is that, after it had been shown that plague could be transmitted by these parasites, the proof that *epidemic* plague was thus caused would still remain to be sought, and could be furnished only by an epidemiological study of the field-facts. It is towards this that I am now able, I submit, to offer a contribution. All that is required to support the conclusion drawn is the laboratory proof that this mode of diffusion of the infection is possible. And this, also, seems now to have been given, not merely by MM. Raymond and Gauthier at Marseilles, but also by Dr. Elkington at Bombay, whose observations are confirmatory of Simond's original experiments made in India as much as five years ago. There are points which still remain to be elucidated. For instance, the facts, as they appear to me, seem to require that the flea should be able still to communicate the virus many hours, and even some days, after it has received it; but, however that may be, this and other such details can be investigated only in the laboratory, and can be determined only by direct experiment. In the meantime I venture to express a hope that the field of epidemic plague, which has hitherto been given over almost entirely to the bacteriologist, and to those who have relied on inferences drawn from his carefully-guarded experiments, may soon begin to be laboured by the professed epidemiologist, whose peculiar function it is to discover and exhibit the phenomena of communicable diseases as they are manifested under the variable conditions of daily life.

J. ASHBURTON THOMPSON.

APPENDIX.

Appendix.

TABLE showing Serial Numbers, Date of Attacks, Adjudged Places of Infection, and grouping of 139 cases of Plague, together with references to the paragraphs in which they are mentioned.

Serial Number.	Date of Attack.	Adjudged Place of Infection.	Area.															Reference number to paragraph in Report.
			South Central. 1	Paddington. 2	Chippendale. 3	Alexandria. 4	Waterloo. 5	Central. 6	Darling Harbour. 7	Woolloomooloo. 8	Camperdown. 9	North Central. 10	S.W. Central. 11	S.E. Central. 12	Pyrmont. 13	Not within any named area. 14	Undetermined. 15	
	1901.																	
1	4 Nov....	Exton's Store, Hay-street, City	•	...	...	...	...	...	...	...	...	...	...	...	...	...	...	77
2	8 Dec. ..	Undetermined	...	...	...	...	...	...	...	...	...	...	...	...	...	...	•	85
	1902.																	
3	10 Jan. ...	145, New South Head Road, Paddington	...	•	...	...	...	...	...	...	...	...	...	...	...	...	...	90
4	12 ,, ..	285, Castlereagh-street, City.....	•	...	...	...	...	...	...	...	...	...	...	...	...	...	...	97
5	16 ,, ...	145, New South Head Road, Paddington	...	•	...	...	...	...	..	...	...	...	...	..	...	...	...	90
6	20 ,, ...	147, ,, ,, ,, ...	...	•	...	...	...	...	...	...	...	...	...	...	...	...	...	90
7	19 ,, ...	115, ,, ,, ,, ...	...	•	...	...	...	...	...	...	...	...	...	...	...	...	...	90
8	19 ,, ...	147, ,, ,, ,, ...	...	•	..	...	...	..	...	...	...	..	...	...	...	...	...	90
9	4 Feb..	Undetermined	...	...	...	...	...	...	...	...	...	...	...	...	...	...	•	45
10	5 ,, ...	171, George-street West, City	...	...	•	...	...	...	...	...	..	...	...	...	...	...	...	101
11	6 ,, ...	8, Henderson-road, Alexandria	...	...	...	•	...	...	...	...	...	...	...	...	...	...	...	101
12	5 ,, ...	167, George-street West, City	...	...	•	...	...	...	...	...	...	..	...	...	...	...	...	101
13	7 ,, ...	165, New South Head Road, Paddington	...	•	...	...	...	...	...	...	...	...	...	...	...	...	...	92
14	10 ,, ...	165, ,, ,, ,, ...	...	•	...	..	...	...	...	...	...	...	...	...	...	...	...	93
15	10 ,, ...	342, Glenmore-road, Paddington	...	•	...	...	...	...	...	...	...	...	...	...	...	...	...	94
16	9 ,, ..	376, Pitt-street, City	•	...	...	..	...	...	...	...	...	...	...	...	...	...	...	100
17	11 ,, ...	217, New South Head Road, Paddington	...	•	...	...	...	...	...	...	...	...	...	...	...	...	...	94
18	14 ,, ...	Her Majesty's Theatre, Pitt-street, City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	212
19	14 ,, ...	,, ,, ,, ...	...	...	...	...	...	•	.	...	...	...	...	...	..	...	...	213
20	15 ,, ...	,, ,, ,, ...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	214
21	12 ,, ...	,, ,, ,, ..	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	211
22	16 ,, ...	George Hotel, Pitt-street, City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	131
23	14 ,, ..	232, Sussex-street, City	...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	124
24	18 ,, ...	118, Crown-street, City	...	..	...	...	...	...	...	•	...	...	...	...	...	...	...	198
25	18 ,, ...	39, Sussex-street, City	...	..	..	...	...	...	•	...	...	...	...	...	...	...	...	127
26	19 ,, ...	Criterion Hotel, 258, Pitt-street, City..	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	199
27	22 ,, ...	,, ,, ,, ...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	199
28	22 ,, ...	224, Sussex-street, City	...	..	...	..	...	...	•	...	...	...	...	...	...	...	...	128
29	21 ,, ...	Criterion Hotel, 258, Pitt-street, City..	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	199
30	21 ,, ...	118, Crown-street, City	...	...	...	...	...	...	...	•	...	..	...	..	...	...	...	198
31	23 ,, ...	Criterion Hotel, 258, Pitt-street, City...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	199
32	22 ,, ...	,, ,, ,, ...	...	...	...	...	...	•	...	...	...	..	...	...	...	...	...	199
33	25 ,, ...	George Hotel, 186, Pitt-street, City ...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	131
34	24 ,, ...	47, Market-street, City	...	..	...	...	...	•	..	...	...	...	...	...	...	..	...	217
35	22 ,, ...	30, Botany-road, Alexandria	...	...	...	•	...	...	...	...	...	...	...	...	...	...	...	109
36	25 ,, ...	68, ,, ,, ...	...	...	..	•	...	...	...	...	...	...	...	...	...	...	...	110
37	20 ,, ..	68, O'Connor-street, Chippendale.....	..	...	•	...	...	...	...	...	...	...	...	...	...	...	...	102
38	22 ,, ...	Undetermined	...	...	...	...	...	...	...	...	...	...	...	...	...	...	•	45
39	24 ,, ...	Criterion Hotel, 258, Pitt-street, City...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	199
40	25 ,, ...	,, ,, ,, ...	...	...	..	...	...	•	...	...	...	...	...	...	...	...	...	199
41	27 ,, ...	482, George-street, City.....	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	134
42	27 ,, ...	49-51, Sussex-street, City	...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	128
43	27 ,, ...	47, Market-street, City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	217
44	27 ,, ...	Undetermined	...	...	...	...	...	...	...	...	...	...	...	..	...	...	•	45
45	1 Mar....	30, Botany-road, Alexandria.....	...	...	...	•	...	...	...	...	...	...	...	..	...	...	...	...
46	3 ,, ...	General Post Office (?), City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	131
47	27 Feb. ...	17, Brisbane-street, City	...	...	...	...	...	...	...	...	...	...	...	•	...	...	...	...
48	27 ,, ..	Undetermined	...	...	...	...	...	...	...	...	...	...	...	..	...	...	•	45
49	28 ,, ...	237, Pitt-street, City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	134
50	2 Mar....	Undetermined	..	...	...	...	...	...	...	...	...	...	...	...	...	...	•	45
51	3 ,, ...	251-257, Pitt-street, City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	134
52	11 ,, ...	Central Exchange Coffee Palace, York-street, City.	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	204
53	11 ,, ...	,, ,, ,, ...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	204
54	10 ,, ...	Undetermined	...	...	...	...	...	...	...	...	...	...	...	...	...	...	•	45
55	12 ,, ...	135, King-street, City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	134
56	10 ,, ..	123, Sussex-street, City.....	...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	128
57	10 ,, ...	170, Pitt-street, City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	134
58	5 ,, ...	Undetermined	...	...	..	...	..	...	...	...	...	...	...	...	...	...	•	45
59	4 ,, ...	Barker's-lane, off Bathurst-street, City	...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	128
60	13 ,, ...	Central Exchange Coffee Palace, York-street.	...	...	..	...	...	•	...	...	...	...	...	...	...	...	...	204
61	13 ,, ..	77, George-street, Camperdown	...	...	...	...	...	...	...	...	•	...	...	...	...	...	...	137
62	16 ,, ...	5, Chambers-street, City	...	...	•	...	...	...	...	...	...	...	...	...	...	...	...	102
63	15 ,, ...	Undetermined	...	...	..	...	...	...	...	...	...	...	...	...	...	...	•	45
64	14 ,, ...	13, Bridge-street, City	...	...	...	...	...	...	...	...	...	•	...	...	...	...	...	218
65	15 ,, ...	,, ,, ...	...	...	...	...	...	...	...	...	...	•	..	...	...	...	...	218
66	16 ,, ...	,, ,, ...	...	...	...	..	...	...	...	...	...	•	...	...	...	...	...	218
67	18 ,, ...	111, York-street, City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	131
68	18 ,, ...	73, Engine-street, City	...	...	...	...	...	...	...	...	...	...	•	...	...	...	...	...
69	13 ,, ...	425, George-street, City.....	...	...	...	..	...	•	...	...	...	...	...	...	...	...	...	204
			1		3	4	5	6	7	8	9	10	11	12	13	14	15	

Serial Number.	Date of Attack.	Adjudged Place of Infection	Area.															Reference number to paragraph in Report.
			South Central. 1	Paddington 2	Chippendale. 3	Alexandria. 4	Waterloo. 5	Central. 6	Darling Harbour. 7	Woolloomooloo. 8	Camperdown. 9	North Central. 10	S.W. Central. 11	S.E. Central. 12	Pyrmont. 13	Not within any named area. 14	Undetermined. 15	
	1902.																	
70	17 Mar....	13, Bridge-street, City	...	...	...	...	...	...	...	...	...	•	...	...	...	...	...	218
71	16 ,, ...	13, ,, ,,	...	...	...	...	...	...	...	...	..	•	...	...	...	...	...	218
72	17 ,, ...	Barque "Eulomene" (excepted)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	•	66
73	19 ,, ...	90, Wyndham-street, Alexandria	...	...	..	•	...	...	...	..	...	...	...	...	...	...	...	108
74	19 ,, ...	Undetermined	...	...	...	...	...	...	...	..	...	...	...	...	...	...	•	45
75	20 ,, ...	39, Market-street, City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	131
76	16 ,, ...	105, King-street, City	...	...	...	...	..	•	...	...	...	...	...	...	...	..	...	134
77	26 ,, ...	109, Quay-street, City	...	...	...	...	...	...	...	...	...	...	•	...	...	...	...	...
78	24 ,, ...	Saxton and Binn's timber yard, Blackwattle Bay.	...	...	...	...	...	...	..	...	...	...	...	...	•	...	...	220
79	22 ,, ...	14, John-street, Waterloo	...	...	...	...	•	...	...	...	...	...	...	...	...	..	...	112
80	25 ,, ...	134, King-street, City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	134
81	25 ,, ...	Strand Arcade, Pitt-street, City	...	...	...	...	...	•	...	...	...	...	...	...	...	...	...	131
82	21 ,, ...	16, Dick-street, Chippendale, City	...	...	•	...	...	...	...	...	...	...	...	...	...	...	...	205
83	26 ,, ...	117, Gipps-street, Pyrmont, City	...	...	...	...	...	...	...	...	...	...	...	...	•	...	...	205
84	26 ,, ...	267, Pitt-street, City	...	...	...	..	...	•	...	...	..	...	...	...	...	..	...	134
85	27 ,, ...	119, Gipps-street, Pyrmont, City	...	...	...	...	...	...	...	...	...	...	...	...	•	...	...	206
86	27 ,, ...	Undetermined	...	...	...	...	...	...	...	...	...	...	...	...	...	...	•	45
87	28 ,, ...	,,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	•	45
88	27 ,, ...	Union Co.'s Wharf, Margaret-street	...	...	...	...	...	...	•	...	...	...	...	...	...	..	...	267
89	22 ,, ...	Miller's timber yard, Duncan-street	...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	128
90	31 ,, ...	20, John-street, Waterloo	...	...	...	...	•	...	...	...	..	..	...	...	...	...	...	112
91	2 April..	119, Gipps-street, Pyrmont	...	..	...	...	...	...	..	...	...	...	...	...	•	..	...	206
92	29 Mar....	16, Dick-street, Chippendale	...	...	•	...	...	...	..	...	...	...	...	...	...	...	...	205
93	3 April..	137, Liverpool-street, City	•	...	...	...	...	...	...	...	...	...	...	...	...	...	...	100
94	3 ,, ...	Undetermined	...	...	...	...	...	...	...	..	...	...	...	...	...	...	•	45
95	16 Mar....	173, Goulburn-street, City	...	...	...	...	...	...	...	...	...	..	•	...	...	...	...	...
96	5 April..	Undetermined	...	...	...	...	...	...	...	...	...	...	...	...	...	...	•	45
97	6 ,, ...	40, Riley-street, Woolloomooloo	...	...	...	...	...	...	...	•	...	...	...	...	...	...	...	...
98	13 ,, ...	1, Bourke-street, Waterloo	...	...	...	...	•	...	..	...	...	...	...	...	...	...	...	112
99	12 ,, ...	Buckle's Wharf, Blackwattle Bay	...	...	...	...	..	...	..	...	...	...	...	...	•	...	...	220
100	18 ,, ...	3, Rennie-street, Redfern	..	..	...	...	...	...	...	...	...	...	..	...	...	•	...	181
101	16 ,, ...	Undetermined	...	...	...	...	...	...	...	...	...	...	...	...	...	...	•	45
102	18 ,, ...	89A, George-street West, City	...	...	•	...	...	...	...	...	...	...	..	...	...	...	...	102
103	19 ,, ...	Undetermined	..	..	...	...	...	...	...	...	...	..	..	...	...	...	•	45
104	20 ,, ...	Gillies' Bond, Grafton Wharf	...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	124
105	20 ,, ...	66, O'Connor-street, Chippendale	...	...	•	..	...	...	...	...	...	...	...	...	...	...	...	102
106	20 ,, ...	2, Bathurst-street, City	...	...	...	...	...	...	•	...	...	...	...	...	...	...	...	128
107	23 ,, ...	60, Phillip-street, Alexandria	...	...	...	•	...	...	...	...	...	...	...	...	...	..	...	111
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111	28 ,, ...	,,	...	...	...	...	...	...	...	...	...	...	...	...	..	...	•	45
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113	30 ,, ...	59, Goulburn-street, City	•	...	...	..	...	...	...	...	...	...	...	...	...	...	...	100
114	24 ,, ...	60, William-street, Woolloomooloo	...	...	...	...	...	...	...	•	...	...	...	...	...	...	...	...
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