

XXIII. OBSERVATIONS MADE IN FOUR VILLAGES IN THE NEIGHBOURHOOD OF BOMBAY.

- I. Introduction.
- II. Observations in Sion.
- III. Observations in Wadhala.
- IV. Observations in Parel.
- V. Observations in Worli.

I. INTRODUCTION.

We have already drawn attention to the many difficulties which surround an epidemiological study of plague in a city like Bombay and have pointed out that these difficulties might be overcome to a considerable extent if smaller, less scattered, and more isolated communities were put under observation. For this purpose we chose four villages in the neighbourhood of Bombay, namely Sion, Parel, Wadhala and Worli, and two in the Amritsar District of the Punjab, to wit, Kasel and Dhand. In all these villages plague had annually recurred for several years past.

We propose now to describe the course of events in the four Bombay villages.

These villages were selected for the reasons that they occupied isolated positions, and that the inhabitants of at least three of them followed an employment (as fishermen and agriculturists) which kept them confined for the most part to their villages and to the tract of country immediately surrounding them. It was considered, therefore, that the chances of importation of infection from Bombay City were small, thus rendering it less difficult to inquire into the source of infection of each case of plague as it occurred. Moreover, one of the main objects we had in view was to watch carefully for the first cases of rat and human plague and to discover, if possible, their origin and relationship.

As a first step a census of the inhabitants was taken and a detailed examination of each village was subsequently made. For the purpose of this census special "Census Cards" were utilised, on which particulars including the name, age, sex, caste and occupation of every inhabitant were recorded, all these details being entered by one of the members of the Commission.

In order to facilitate reference to events which might happen in connection with a particular house, a system of numbering the houses was adopted. The whole village was partitioned out into convenient divisions, consisting of from 20 to 50 buildings: these divisions we termed 'blocks.' A 'building' we defined as a structure surrounded on all sides by open space and occupied by one or more families. Lastly a 'house,' according to our system of numbering, corresponds to the living room or rooms of a single family. The buildings and houses were numbered in order serially. According to this nomenclature a small hut consisting of a single room and inhabited by a single family is entitled to the appellation of a 'building' as well as of a 'house.' Maps also were prepared, showing each house exactly to scale¹.

A daily collection of rats was organised; traps were daily set in many of the houses, the buildings being systematically trapped in this way. This part of the scheme was supervised by native clerks, each assisted by two coolies residing in the villages and familiar with their inhabitants. These clerks proved useful in obtaining for us early information regarding plague rats and cases of human plague. Further, the inhabitants were instructed and constantly reminded that all dead rats which were found should be handed over to our clerks. The live rats caught in the traps and any dead rats which were obtained were daily brought to the laboratory and examined in the manner we have already described.

As a means of gaining the confidence of the people a dispensary was opened during the epidemic period, and was placed in charge of a Hospital Assistant, whose duty it was to keep himself acquainted with any occurrences of importance from our point of view.

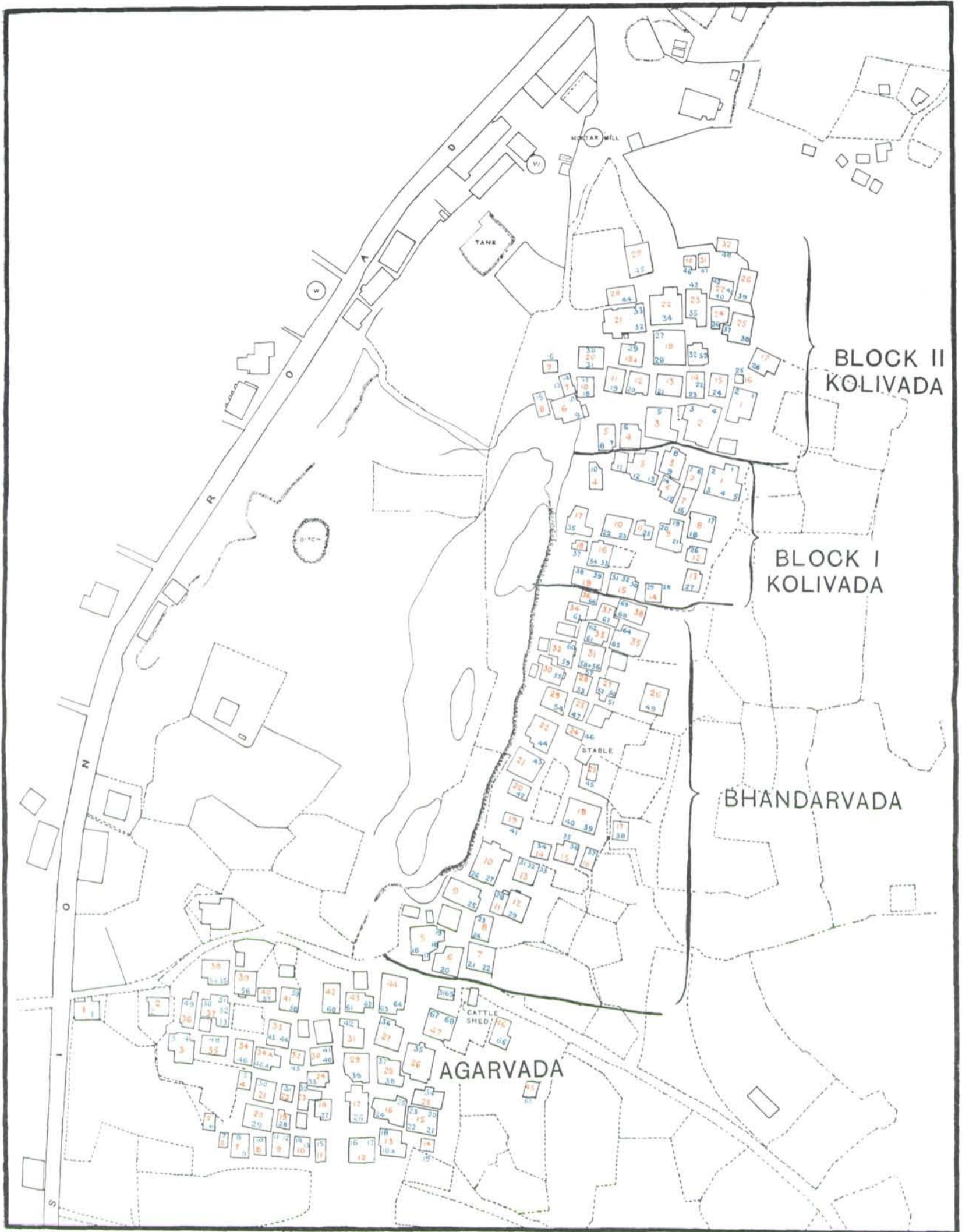
We sought on more than one occasion to secure the co-operation of the village headmen, but although apparently willing to give us help, it was found by experience that but little assistance was to be looked for from these men or from the villagers themselves. Fortunately no active opposition was met with, but our difficulties in carrying out the scheme

¹ The key map of Sion Village is reproduced below (Map I): the other villages were dealt with in the same way.

MAP I

SION VILLAGE

Key to census numbers



SION VILLAGE
Key to census numbers

Scale 100 feet to five-eighths of an inch

- Black = Block number
- Red = Building number
- Blue = House number

were greatly increased by the fact that the natives here are much less under the direct influence of their headmen than in the Punjab villages, and that to an equal degree the control of the local authorities over the headmen is in many ways much less personal and effective than in the up-country villages. Still, as the following narrative shows, our efforts in investigating the course taken by plague in these villages cannot be regarded as altogether fruitless.

With this introduction we may now pass on to describe the course of events in each village, dealing first with Sion, in which a most interesting experiment was carried out.

II. OBSERVATIONS IN SION VILLAGE.

Section A. *A description of the village in which the observations were carried out.* (Map I.)

(a) *Its situation, inhabitants, etc.*

Before entering into details of the observations it is necessary first of all to give a general account of the village in which they took place. This is a small village or hamlet named Sion¹. It lies in a picturesque situation about eight miles to the north of the European quarter of Bombay City, and about three miles from the northern limit of the island, on the east side of one of the main roads leading from the city to the causeway which connects Bombay with the neighbouring island of Salsette. The village is set somewhat back from the road so that it presents quite an isolated appearance, being surrounded by open country. The inhabitants of Sion at the present day are descendants of the earliest settlers in Bombay.

Nominally, the village is divided from north to south into three nearly equal parts. The most northerly is called Koliwada and is inhabited chiefly by kolis or fishermen; the majority of these are Hindus, but a certain proportion are native Christians. The southernmost part is named Agriwada—literally the village of the Agris. Bounded by Koliwada on the north and by Agriwada on the south, and consequently occupying the middle of the village, there is a part known as Bhandarwada. The aboriginal inhabitants were Bhandaris—a caste, the members of which follow the occupation of toddy drawers. Some of the

¹ The name has been derived from "Simva," *i.e.* the boundary hamlet—the last inhabited spot before crossing the strait to Salsette. Edwardes, *History of Bombay*, p. 11.

present inhabitants still follow their hereditary calling and may be seen climbing the palm trees in the village and in its vicinity, in order to collect in earthen pots the juice which drips from the incised crown of the trees. Most of them, however, work in the neighbouring fields. As is indicated in the accompanying map (Map I) a ridge of rock of volcanic origin bounds Bhandarwada and a part of Koliwada on the west side. The entire village is built on gently undulating ground—the highest point being at the junction of Koliwada and Bhandarwada.

The population of each part as ascertained by our census was as follows:

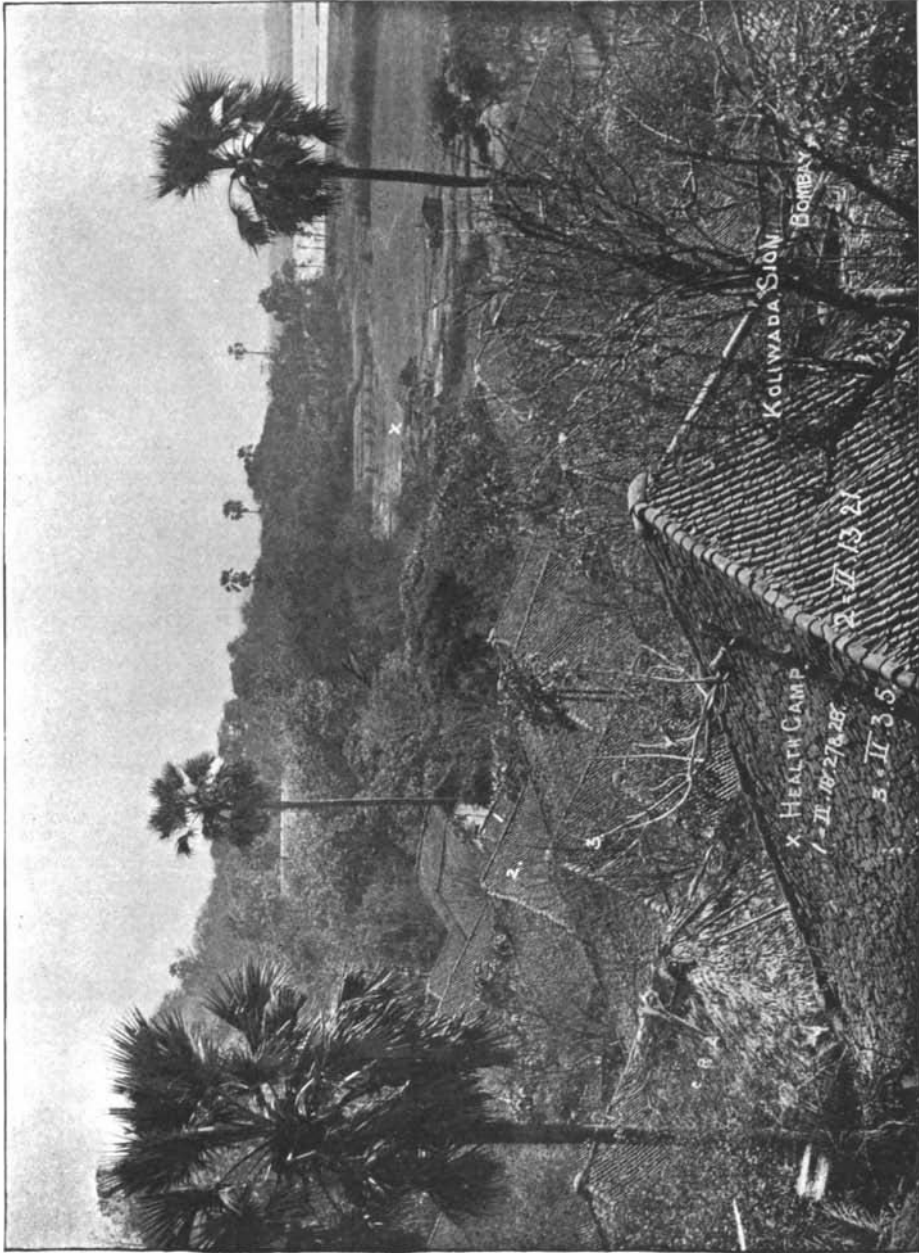
Koliwada	...	...	...	375
Agriwada	...	...	...	325
Bhandarwada...	...	...	...	250
			Total	950

(b) *Construction of the buildings.*

The construction of the buildings merits attention, since according to our view their peculiar features play a part in the liability of their occupants to plague infection.

A glance at Map I and at Plates XXVIII and XXIX will show that the buildings are isolated from each other and that in no instance are they placed back to back or in rows—in this respect differing entirely from the complex arrangements of the houses in a Punjab village. The great majority have only one story. The outer walls are built of unhewn stones (Plate XXX) cemented together with clay, the foundations extending to a considerable depth below the surface of the ground. The walls are occasionally covered with a layer of limewash. In front of each building there is a verandah (Plates XXX, XXXI), the roof of which is formed of bamboo laths supporting tiles of country make. This verandah is often surrounded on three sides by a low mud wall, and this and its mud floor have a certain finish imparted to them by the periodical application of cowdung.

The level of the floor of the verandah and of the inner rooms is often 4—5 ft. or more above the level of the surrounding ground—a provision which must aid in keeping the houses dry in the monsoon months. The floor of the rooms consists of clay, beaten down till it is firm and smooth, renewed every few years when it becomes uneven, and covered with a layer of wet cowdung, which quickly dries forming a neat and clean surface. The cowdung is renewed at short intervals. The roof consists of country tiles (Plates XXVIII to XXXI), laid upon bamboo



Sion Koliwada, showing the house (t) in which plague began and the site of the health camp (x).



Sion Koliwada: showing houses B, C and F (see text and map IV).



Sion Koliwada: showing tiles, verandah, etc.



Sion Koliwada: House B.



Sion Agriwada: House P (see map VII).

laths and slopes upwards on the four sides from the eaves towards a central point.

The internal arrangements in the buildings are simple. The rooms are separated off by lath partitions plastered with mud. There is often a rude loft enclosed within the sloping sides of the roof and used as a general lumber-room. The cooking place, usually surrounded by shining copper and brass pots, occupies a corner of one of the rooms. Another corner is set apart for the reception of the household gods. The people have strong prejudices against natives of another caste and Europeans approaching too near these places, so that in examining the houses it was necessary to respect the feelings of the owners in this regard. Bundles of firewood and cowdung cakes (used as fuel) are stacked in odd recesses, and collections of dried fish and of grain find temporary resting places on the floors.

(c) *Conditions as regards sanitation of the buildings and of the village generally.*

The houses are kept moderately clean, although they usually harbour a good deal of material which is best included in the category of rubbish—the kind of property which is of little apparent use, but which poor people set store by in the hope that some day it may prove useful.

It is difficult, if not impossible, to judge of the adequacy or inadequacy of the ventilation in these houses by the ordinary standards. A mere estimation of the number of cubic feet of air available for each inmate would certainly convey an erroneous idea of the conditions as regards ventilation. It must be remembered that the doors, at least during the day, are kept open and that the windows, consisting of a grid of iron bars with ill-fitting wooden shutters—sometimes with no shutters—are so defective in construction as practically to act as ventilators (Plates XXX, XXXI). The outer walls are often rat riddled and the mud-cement, when it becomes very dry, cracks and gives rise to fissures; in some buildings even large cracks may be seen between the stones of the walls. Lastly, the country-tiled roof forms an admirable ventilator, which is assisted in many houses by large gaps between the top of the outer walls and the eaves of the roof. It seemed to us, in short, that the ventilation of the houses was adequate, and as evidence of this belief it may be noted that on entering any of them we never encountered the disgusting odour due to human emanations, or even the sensation of closeness which is so common a feature of the houses of the very poor in our country.

With regard to the lighting of the houses it must be stated that

many of them are dark but this is surely an advantage in the case of people who for the greater part of the day labour under a fierce and glaring sun.

We fear that the description we have given of mud floors covered with cowdung and of mud-cemented walls conveys to the reader accustomed to live in a substantial house of stone and mortar hermetically sealed against the rigours of a cold and damp climate, an idea of a primitive mode of living with a total disregard for the most ordinary laws of sanitation. And yet these houses give the impression, to one who is familiar with them, that they are excellently adapted to the conditions of life which obtain in a tropical climate. Doubtless in the monsoon months the houses are damp; it would be absurd, nevertheless, to associate the dangers of exposure to damp so familiar to every inhabitant in a country like our own, with the warm and moist conditions that exist in Bombay. Moreover, during the plague season the houses are as dry as a nearly total absence of rain for several months and a tropical sun can render them.

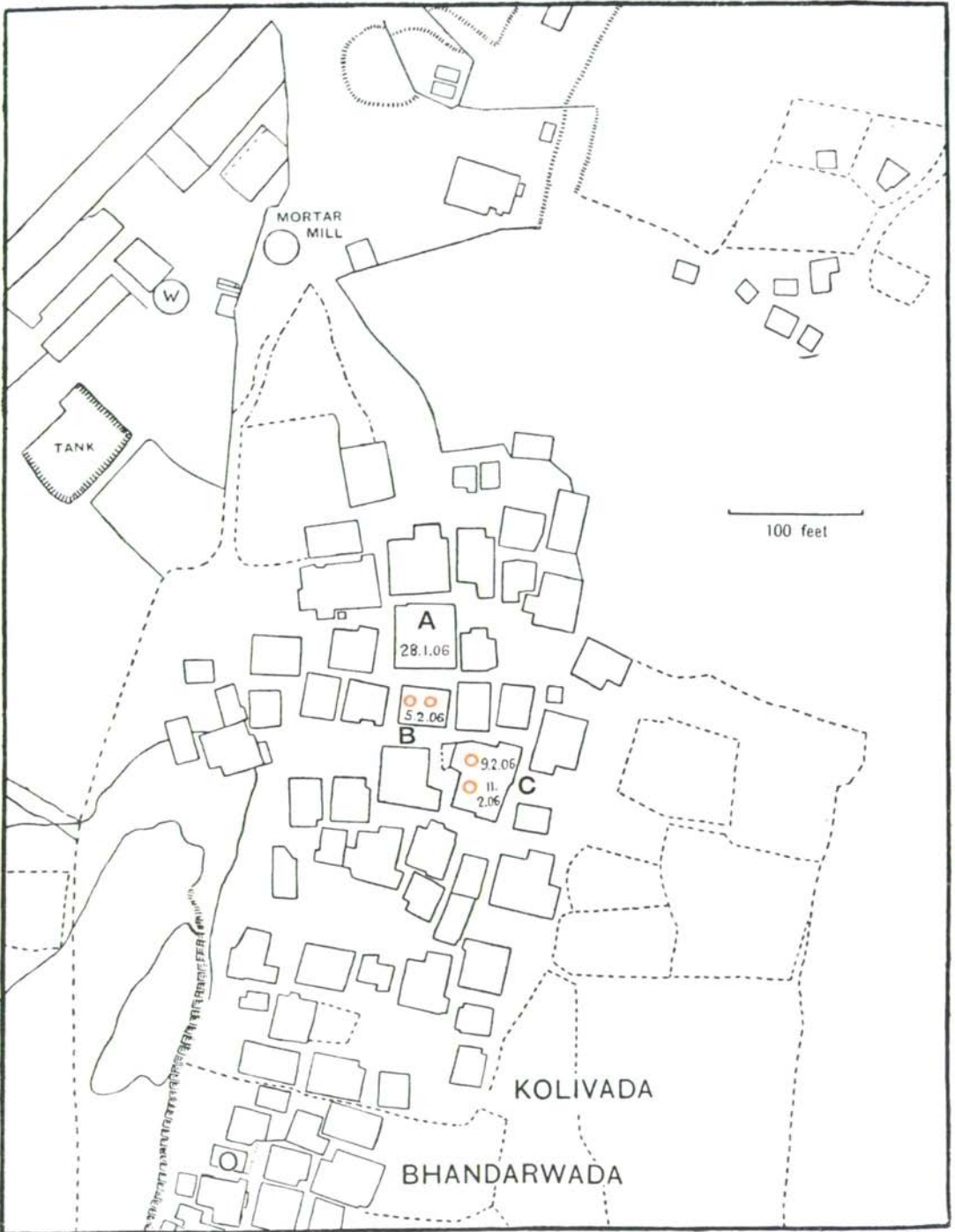
When we come to consider the sanitary conditions which relate to the disposal of refuse, of waste water and of excreta it must be said that in this respect they leave much to be desired. Proper facilities for the disposal of refuse and excreta are entirely absent. As in many other parts of India the people use the neighbouring fields as latrines. Curiously no nuisance is evident from such a method of disposal. The intense heat of the midday sun and the radiation from the hot ground have a powerful desiccating effect on human excreta and quickly render them inodorous.

The waste water from the houses finds its way along a channelled stone let through the wall and projecting a foot or so beyond. Occasionally even this simple expedient is dispensed with and the water drips through a hole in the wall from which it drains into the ground or finds its way into a cesspool, formed of a hole about 4 ft. in diameter dug out of the ground and situated a distance of only a few feet from the house. No gullies or drains are to be found in the village.

The water supply is derived from the municipal water pipes and is placed at the disposal of the people by means of stand pipes, situated at one or two convenient spots in the village.

The personal habits of the villagers are on the whole good. Like all Hindus they perform frequent ablutions. Their physique compares favourably with that of natives living in similar circumstances in Bombay City. During the period the village was under surveillance

MAP II



SION VILLAGE

Shows events which happened during the second period

○ Date of attack of human case

the incidence of sickness and death from causes other than plague was remarkably light. Though poor the villagers are not poverty stricken, and indeed appear to live a moderately comfortable existence.

Section B. *Observations in Koliwada.*

It will be convenient and will tend to clearness if we divide the events which happened in Koliwada under three headings, namely:

1. The First Period—from the beginning of the investigation in November 1905 to the 28th January 1906.

2. The Second Period—from the 28th January 1906 to the 12th February 1906.

3. The Third Period—from the 12th February 1906 to the end of the experiment, that is, to the 16th April 1906.

A. *Events relating to the First Period, i.e. from November 1905 to the 28th January 1906.*

It has already been mentioned that arrangements were made whereby we might become aware of the first plague rat and of the first human case that occurred in the village. The houses were systematically trapped for rats, traps being set in several houses every day, and the village clerks and their coolies were instructed to keep a look out for dead rats and to remind the villagers of our desire to obtain any rat found dead in their houses. The daily catch of rats caught alive in traps was examined according to exactly the same procedure as the rats brought to the laboratory from the City¹.

The history of the period we are considering may be dismissed very briefly. So far as we could ascertain the rat population of the village remained free of plague and no human case occurred.

B. *The Second Period—from the 28th January 1906 to the 12th February 1906. (Map II.)*

On a visit to the village on the 29th of January we learned that on the previous day a dead rat had been found in building A². Although

¹ During this period 465 rats were trapped alive from houses in the *whole* village of Sion. These included 381 *M. rattus*, 81 musk rats and 2 mice. Not a single *M. decumanus* was found.

² For ease of description we have departed in the case of certain buildings requiring detailed notice from the nomenclature adopted by us during the investigation. These buildings will hereinafter be referred to by letters of the alphabet given to them in the order of the earliest event occurring in them which pointed to plague infection.

at this time we had no reason to believe that the rat was plague infected yet as a matter of precaution two guinea-pigs were put into the building; they did not contract plague.

On the 7th February some of the villagers informed us in a casual manner that there was a case of plague in one of the houses and that the inhabitants of Koliwada had resolved to evacuate the village, and to go into camp. It was evident that events of importance to us were being withheld and we were naturally disappointed at the distrust shown by the people.

Although it appeared that the main objects of the investigation were frustrated yet it was thought advisable to pursue the inquiry as far as possible. As a result several facts of importance came to light and we are now in a position to state the essential data which pertain to this period. These are briefly:

I. On 28th January the occupants of A according to their own admission found a dead rat in their house and threw it away. On the same day these people and their neighbours in the other house of the building vacated it and went to live in a building a short distance away, namely building C.

II. On 5th February Havloo Akar was attacked with plague in B a house adjoining A; she died on 9th February. Raghunatu Lakshman was attacked with plague on the same day in the same building; he died on 8th February.

III. On 9th February Budhia Sukur was attacked with plague in C; he died on 11th February.

IV. On 11th February Halia Bhiwa, who previous to 28th January lived with his parents in A, was attacked with plague in C; he died on 13th February.

V. The Koliwada villagers began to evacuate the village on 8th February and by the 11th February they had almost all gone into camp.

Although it is impossible to state that the dead rat found in A had died of plague yet at this time we thought it advisable to make inquiries into the matter, as there was a very strong presumption that it was plague infected. Several suspicious circumstances pointed in this direction. We regarded the fact that the families living in A vacated their houses on the day the rat was found as suspicious, because the villagers adopt this precaution when they become aware during the plague season of an unusual mortality amongst the house rats. These considerations, taken in conjunction with the occurrence of several plague cases in the houses adjoining A made us suspect strongly that

the dead rat found in A was plague infected. We cannot put forward the following account of the results of our inquiries into the matter as altogether trustworthy evidence, since it is founded chiefly upon statements made by people who did not give the impression of telling the whole of the truth. It may be cited, however, as an apt instance of the difficulties met with in carrying out epidemiological investigations in Bombay.

On the 16th January 1906 a young woman named Anna Pascal died in house No. 30 Tankbunder Koliwada, a district in Bombay City; the death was registered as "asthma." Her neighbours stated, however, that she suffered from an acute illness with high fever and a bubo in the groin. This woman, Anna Pascal, was a Christian Koli. In the same district there lived another Christian Koli family, named Tukeram, consisting of an old woman named Pasci and her husband and son. When Anna Pascal died the Tukeram family, including the old woman Pasci, attended the funeral. It is necessary in this connection to point out that in Bombay the native funeral ceremonies are for the most part carried out in the room in which the person dies. The friends, especially the women, congregate in the room and assist the relatives in dressing the corpse before it is removed from the house.

On or about the 21st January Pasci paid a visit to her daughter and grandchildren who lived in building A Sion Koliwada. She stayed with her relatives till the morning of the 28th January, the date of the discovery of the dead rat in the house; and then returned to her own house in Tankbunder Koliwada. She became frightened when the dead rat was discovered knowing full well that she had come from an infected locality; she believed that we or the villagers would attribute the infection of the village to her. We could obtain no information from the old woman Pasci as to having brought with her from her own house to her relatives' house A any clothes or other articles likely to contain infection.

It may be admitted that this account offers a plausible explanation of the origin of the rat epizootic which we believed to have originated in A. The information on which the above account is based was derived in the following way. Cross-examination of the owner of A elicited the fact that the old woman Pasci a short time before coming to live with her relatives in A had attended a funeral. We could not extract any definite information as to the address of the woman whose funeral Pasci had attended, except that she lived in Tankbunder Koliwada. Examination of the records of deaths kept by the registrar

in whose district Tankbunder Koliwada is situated showed that the only death likely to have any connection with the case we were investigating was that of the young woman Anna Pascal, although as we have said the cause of death was registered as "asthma." The discrepancy between the death registration and the neighbours' account of the illness does not in the least detract from the likelihood of the illness having been plague, since it is a matter of common knowledge that in Bombay "asthma" is one of the favourite synonyms used by people who wish to conceal a plague death. Subsequent events proved that the clue we were following was the correct one, for when it was put to Pasci that she had attended Anna Pascal's funeral she at once admitted the fact.

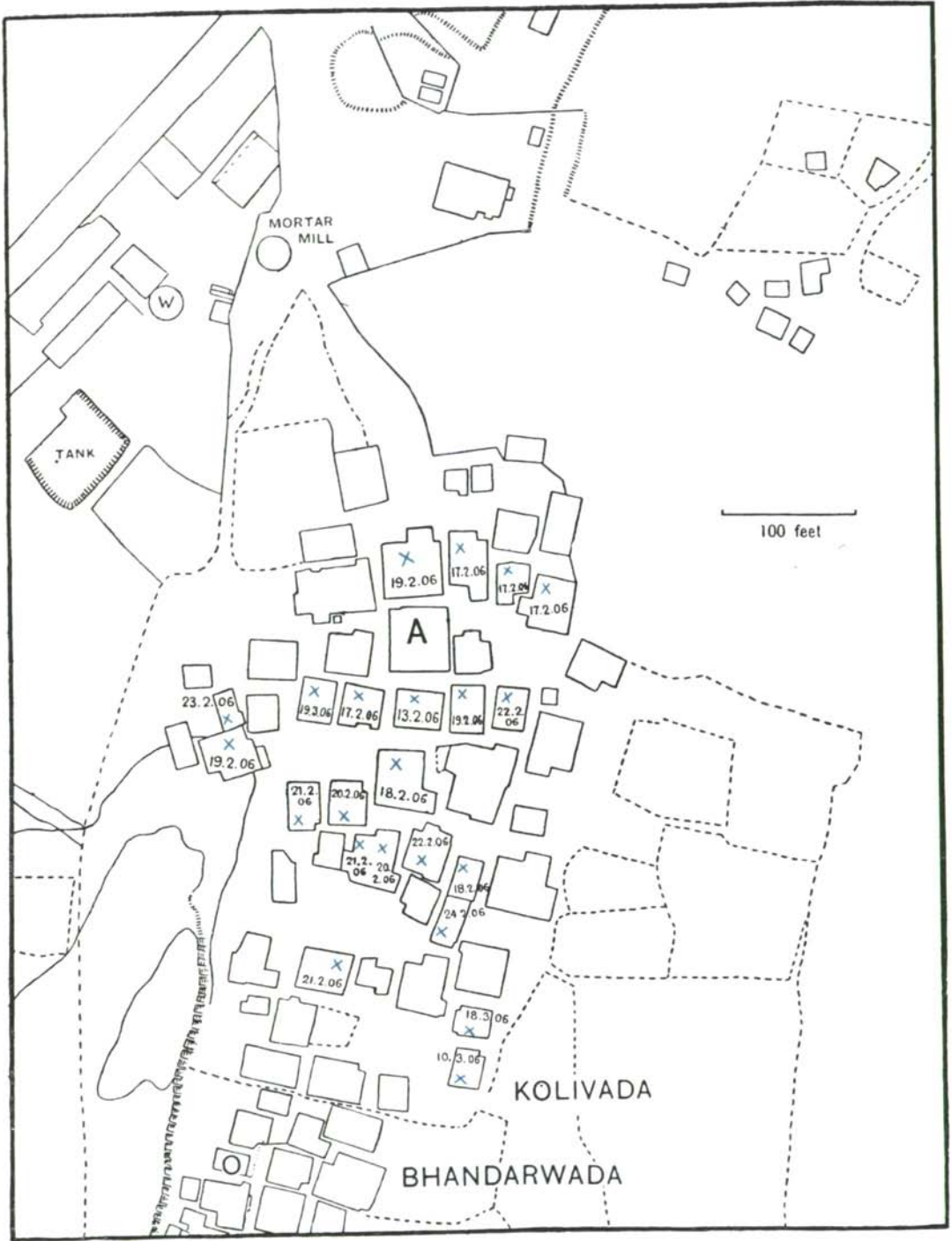
C. *The Third Period—from 12th February 1906 to April 1906.*
(Maps III—VI.)

By the 11th February the Koliwada inhabitants with a few exceptions had removed to a temporary camp in the neighbouring fields, a few hundred yards from the village. This action on the part of the villagers was undoubtedly the outcome of severe lessons learnt during the earlier years of plague in Bombay. For the past four or five years they have been accustomed, acting on their own initiative, to leave the village and to go into camp whenever human deaths associated with dead rats begin to occur. By these people, ignorant as they may be, the significance of a mortality amongst the house rats is thoroughly appreciated. It cannot be doubted that their action in this respect was the best thing that they could do under the circumstances, but it is obvious that by so acting they took away from us all hopes of investigating the relationship of rat and human plague as they may be observed in a non-evacuated village.

We determined, however, to utilise the opportunity experimentally.

Let us now summarise the facts which were at our disposal when the experiment was begun. They were: (1) history of a dead rat found in A; (2) four cases of human plague in the adjoining buildings B and C; (3) an almost completely evacuated village.

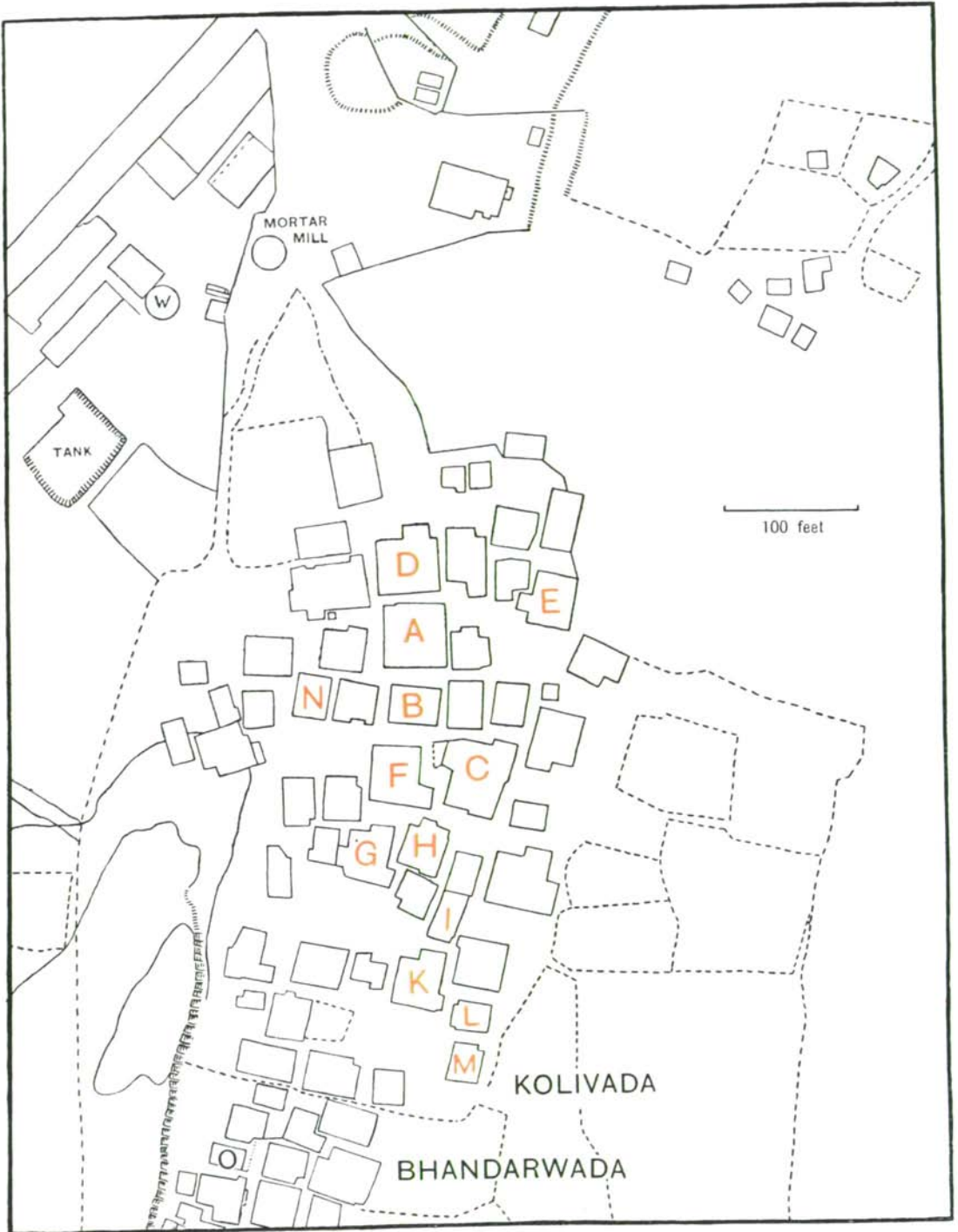
There was good reason to suppose that an epizootic had broken out amongst the rats in the buildings in the vicinity of A. Whether this was a limited epizootic or not it was impossible to say, for we had not succeeded in obtaining any plague rats from this quarter during the second period. Still it occurred to us that this point might be tested



SION VILLAGE

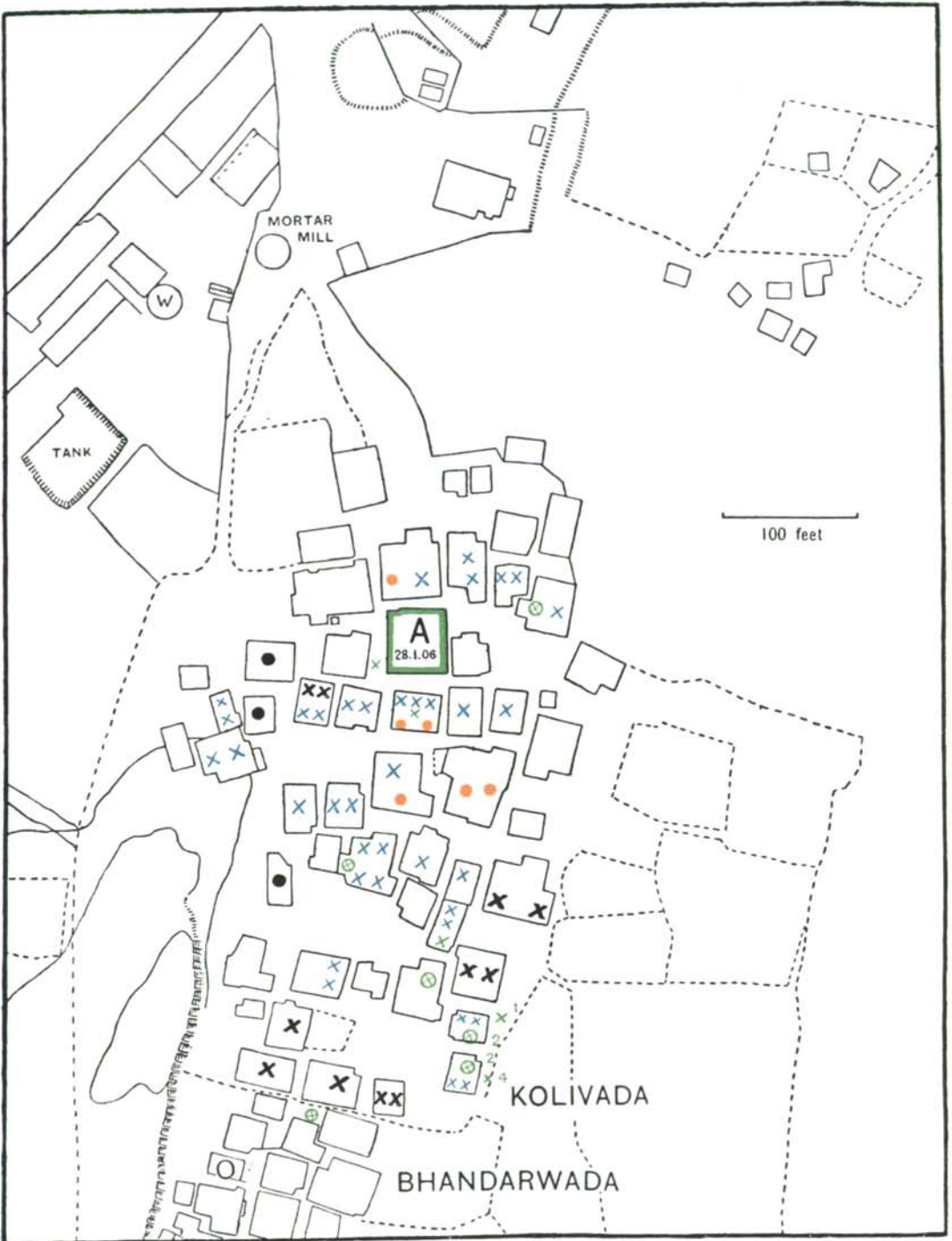
Shows guinea-pigs which died of plague—only the guinea-pig which died earliest in each house being represented together with the date of death

X Guinea-pig died of plague



SION VILLAGE

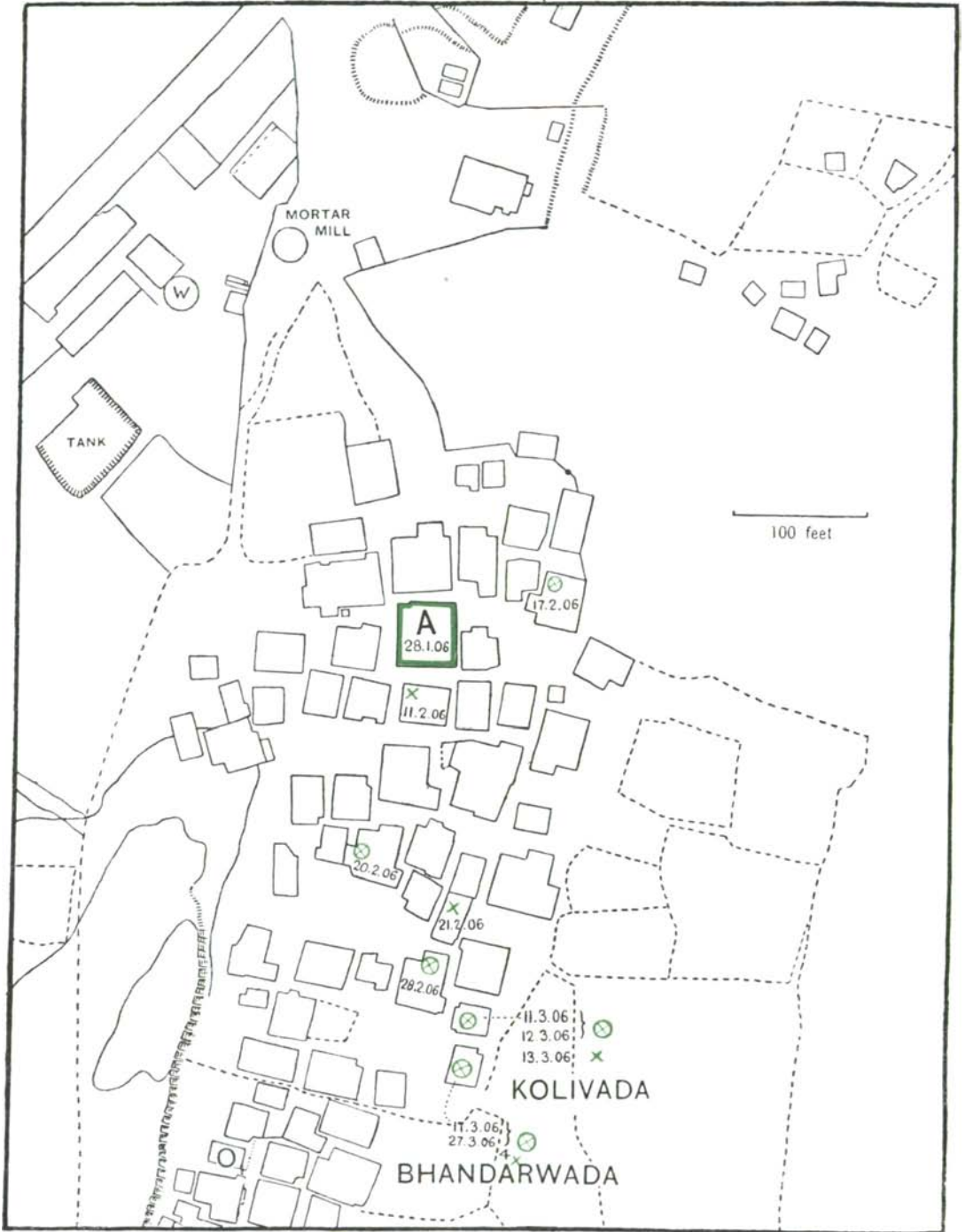
Key to buildings dealt with under the heading "a detailed description of events requiring special notice which happened in certain houses"



SION VILLAGE

Shows all the events which happened in the houses

- | | | |
|---------------------------|--------------------------------|------------------------|
| ● Death (human) | ⊗ Guinea-pig dead of plague | ⊗ Plague rat confirmed |
| ⊗ Mummified or putrid rat | ⊗ Guinea-pig remaining healthy | ● Non-vacated houses |



SION VILLAGE

Showing rats found in Kolivada

⊗ Undoubted plague

⊗ Mummified or putrid

by substituting in the houses throughout the village a guinea-pig population. The advantages of such a procedure were obvious: 1. It would be an easy matter to examine the guinea-pigs for the presence of rat fleas. 2. It suggested itself that it might be possible to establish a relationship between plague rats found by search in the houses, and any plague infection which might become evident amongst the guinea-pigs. 3. The outstanding advantage of such a scheme appeared to be the circumstance that the guinea-pigs were entirely under our control, that they could be kept confined and isolated from each other in the buildings, and that if an epidemic should break out amongst them the objection certainly could not be urged that a guinea-pig in one building had contracted its infection directly from a guinea-pig living in another building.

Briefly it may be said that this scheme was carried out and that it proved successful beyond our expectations.

As the details of the experiment are of necessity somewhat confusing since frequently several events happened at nearly the same time in houses in different parts of the village, we propose in the following account to arrange them under several headings.

1. *An account of the methods adopted in the experiment.*

On the 12th February two guinea-pigs were allowed to run free in each of seven vacated buildings in the immediate neighbourhood of A and as far as possible surrounding it. Within the next few days the range of buildings into which guinea-pigs were put was extended, so that by the 15th February most of the houses in the village sheltered two guinea-pigs. Difficulties were experienced at the outset; for example, we found on visiting, 24 hours later, the first houses into which guinea-pigs had been placed, that in some of them either one or both the animals had been killed by cats. On this account it was found necessary to place the animals in wire cages on the floor of the houses. Again, in some instances we could not gain access to the houses, either because their occupants could not be traced or because they were unwilling that we should enter them. Further, a few houses in the village remained occupied throughout the period of the experiment, so that it seemed unnecessary to add guinea-pigs as their human occupants served as a control.

The animals were examined every day—in the morning and evening—and when a favourable opportunity arose a search was made in the

TABLE I.

Giving the details of guinea-pigs (running about free or in wire cages) which died of plague in the houses in Koliwada. They are arranged with reference to the earliest date of death of a guinea-pig in each house.

Serial No.	House No.	Date when guinea-pig was put in	Date of death	No. of fleas on dead guinea-pig, or before removal to laboratory	Bubo	Remarks
1	II. 13. 21 (B)	10. 2. 06	13. 2. 06	42	Submax.	—
		15. 2. 06	20. 2. 06	0	„	
		15. 2. 06	21. 2. 06	12	„	
2	II. 12. 20	12. 2. 06	17. 2. 06	3	„	—
		12. 2. 06	19. 2. 06	64	„	
3	II. 23. 35	12. 2. 06	17. 2. 06	0	„	—
		12. 2. 06	18. 2. 06	16	„	
4	II. 24. 36	13. 2. 06	17. 2. 06	15	„	—
		13. 2. 06	21. 2. 06	18 rat fleas 1 cat flea	„	
5	II. 25. 37 (E)	14. 2. 06	17. 2. 06	8	„	—
6	I. 2. 7	13. 2. 06	18. 2. 06	5	Rt. submax. Lt. inguinal	—
7	II. 3. 5 (F)	12. 2. 06	18. 2. 06	0	Submax.	Guinea-pig found dead partly eaten by rats.
8	II. 6. 10	15. 2. 06	19. 2. 06	0	„	—
		15. 2. 06	1. 3. 06	1 rat flea 1 cat flea	„	
9	II. 14. 23	12. 2. 06	19. 2. 06	89	„	—
10	II. 22. 34 (D)	12. 2. 06	19. 2. 06	18	„	—
11	I. 5. 13 (G 2)	14. 2. 06	20. 2. 06	0	„	—
		14. 2. 06	22. 2. 06	2	„	
12	II. 4. 6	15. 2. 06	20. 2. 06	0	„	—
		15. 2. 06	20. 2. 06	14	„	
13	I. 5. 12 (G 1)	14. 2. 06	21. 2. 06	6 cat fleas 3 rat fleas	„	—
		14. 2. 06	22. 2. 06	4	„ Rt. inguinal	
14	I. 10. 23	15. 2. 06	21. 2. 06	1	Submax.	—
		15. 2. 06	21. 2. 06	3	„	
15	II. 5. 7	14. 2. 06	21. 2. 06	23 rat fleas 1 cat flea	„	—
16	I. 3. 9 (H)	13. 2. 06	22. 2. 06	12 rat fleas 2 cat fleas	„	—
17	II. 15. 24	12. 2. 06	22. 2. 06	0	„	—
18	II. 7. 14	15. 2. 06	23. 2. 06	4	„	Chronic plague (relatively).
		15. 2. 06	28. 2. 06	3	„	
19	I. 7. 16 (I)	15. 2. 06	24. 2. 06	8	„	—
		15. 2. 06	3. 3. 06	0	„	
20	I. 13. 27 (M)	15. 2. 06	10. 3. 06	0	No definite bubo	Culture from heart-blood. Chloroformed to death.
		15. 2. 06	4. 4. 06	4	Lt. inguinal	
21	I. 12. 26 (L)	15. 2. 06	18. 3. 06	8	Submax.	Submax. phlyctenule.
		15. 2. 06	22. 3. 06	26	„	
22	II. 11. 19 (N)	14. 2. 06	19. 3. 06	0	„	—
		14. 2. 06	23. 3. 06	1	„	

houses for dead rats. The odour of a putrefying rat is quite distinctive and this on more than one occasion led to a search, which resulted in the discovery of one or two dead plague rats. The guinea-pigs were frequently examined for fleas, and in every case those which had a bubo or appeared to be sick were chloroformed for this purpose. The fleas were removed, a note was made of the number and species, and they were then, as a rule, put back into the house. Every sick guinea-pig, after being cleared of fleas, was removed to the laboratory for segregation. The object of this precaution was to prevent the fleas becoming infected from the sick animal when a septicaemia supervened, because otherwise its companion, if still healthy, might contract plague from such infected fleas.

2. *A general description of the epidemic which broke out amongst the guinea-pigs placed in the houses.*

The details of the guinea-pig epidemic have been arranged in Table I and they have also been represented graphically on Map III. The course of events will be best appreciated by a study of the map so that we are exempted from the necessity of describing in detail the progress of the epidemic. The reader will readily perceive that our conjecture proved correct, that widespread infection throughout the village had occurred, probably originating in A.

It will, we think, be granted also that a review of the table leads to the conclusion that the infection spread peripherally from the focus A, especially towards the southern boundary of Koliwada, that is, the part contiguous to Bhandarwada. For full details of all the guinea-pigs which died of plague the reader is referred to Table I.

3. *A detailed description of events requiring special notice which occurred in certain houses.*

In order that the account may be consecutive and thus more easily understood, the houses coming under this heading will be dealt with in the order of the earliest event occurring in them which pointed to the presence of plague infection.

*Building II. 18. 27, 28 (A)*¹.

This building was occupied by two families, both of them Christian Kolis. Since the events which happened in it are of special importance

¹ *i.e.* Block II, building 18, houses 27 and 28; this building being also distinguished as A.

the circumstances connected with it may be briefly recalled. On or about the 21st January the old woman Pasci came from her house in Tankbunder Koliwada in Bombay City and lived here for a week with her daughter and grandchildren. It is probable that she brought with her an infecting agent, at the nature of which we can only guess, acquired perhaps during her attendance at the funeral ceremonies of Anna Pascal, who in all likelihood died of plague. It is interesting to note that, assuming this explanation to be a right one, Pasci herself did not suffer from plague nor in the first instance did any of the occupants of this building.

There can be no doubt that the occupants of A found a dead rat in the house on 28th January, and it is evident that they suspected this rat of being plague infected, for they and their neighbours in the same building vacated their houses on the same day and went to live in C.

TABLE II.

Giving details of guinea-pigs placed in houses in Koliwada which remained healthy till the end of the experiment. They are arranged in order of the House Number.

Serial No.	House No.	Date when put in	Remarks
1	I. 1. 3 & 5	I. 1. 3, 2 guinea-pigs 14. 2. 06 I. 1. 5, 2 guinea-pigs 15. 2. 06	—
2	I. 3. 9 (H)	1 guinea-pig 13. 2. 06	Removed on 20. 2. 06 to laboratory for isolation together with a sick guinea-pig which died of plague.
3	I. 8. 17 & 18	2 guinea-pigs in cage 18. 3. 06	—
4	I. 14. 29	2 guinea-pigs 15. 2. 06	—
5	I. 15. 31	1 guinea-pig in cage 23. 2. 06	—
6	I. 16. 33	1 guinea-pig in cage 23. 2. 06	—
7	I. 19. 39	1 guinea-pig in cage 23. 2. 06	—
8	II. 5. 7	1 guinea-pig 14. 2. 06	Removed on 20. 2. 06 to laboratory for isolation together with a sick guinea-pig which died of plague.
9	II. 11. 19 (N)	2 guinea-pigs 12. 2. 06	Note :—2 other guinea-pigs in this house put in on 14. 2. 06 died of plague on 19. 3. 06 and 23. 3. 06.

Diary of events prior to the experiment.

28. 1. 06. A dead rat was said to have been found and thrown out of (A) on this date. The inhabitants of (A) left their houses and went to live in (C).
5. 2. 06. Havloo Akar was attacked with plague in (B). He died on 9. 2. 06. Raghunatu Lakshman was attacked with plague in (B). He died on 8. 2. 06.
9. 2. 06. Budhia Sukur was attacked with plague in (C). He died on 11. 2. 06.
11. 2. 06. Halia Bhiwa (of II. 18. 27) was attacked with plague in (C). He died on 13. 2. 06.

TABLE III.

Showing Koliwada houses arranged in order of date of the earliest event occurring in them, which pointed to plague infection being present in the house.

Serial No.	House No.	Date of earliest event	Date on which guinea-pig was put into house	Interval between date of putting in guinea-pig and its death	Remarks
1	II. 18. 27 (A)	28. 1. 06	—	—	History of dead rat found.
2	II. 13. 21 (B)	5. 2. 06	—	—	Havloo Akar and Raghunatu Lakshman attacked with plague.
3	II. 2. 3 & 4 (C)	9. 2. 06	—	—	Budhia Sukur attacked with plague.
4	II. 22. 34 (D)	14. 2. 06	—	—	Maribai Amber attacked with plague.
5	II. 12. 20	17. 2. 06	12. 2. 06	5 days	Guinea-pig dead of plague.
	II. 23. 35		12. 2. 06	5 "	" " "
	II. 24. 36		13. 2. 06	4 "	" " "
	II. 25. 37 (E)		14. 2. 06	3 "	In II. 25. 37 plague rat found.
6	I. 2. 7	18. 2. 06	13. 2. 06	5 "	Guinea-pig dead of plague.
	II. 3. 5 (F)		12. 2. 06	6 "	" " "
7	II. 6. 10	19. 2. 06	15. 2. 06	4 "	" " "
	II. 14. 23		12. 2. 06	7 "	" " "
8	I. 5. 12 (G1)	20. 2. 06	—	—	Plague rat found.
	I. 5. 13 (G2)		14. 2. 06	6 days	Guinea-pig dead of plague.
	II. 4. 6		15. 2. 06	5 "	" " "
9	I. 10. 23	21. 2. 06	15. 2. 06	6 "	" " "
	II. 5. 7		14. 2. 06	7 "	" " "
10	I. 3. 9 (H)	22. 2. 06	13. 2. 06	9 "	" " "
	II. 15. 24		12. 2. 06	10 "	" " "
11	II. 7. 14	23. 2. 06	15. 2. 06	8 "	" " "
12	I. 7. 16 (I)	24. 2. 06	15. 2. 06	9 "	" " "
13	I. 9. 19 (K)	28. 2. 06	—	—	Plague rat found.
14	I. 13. 27 (L)	10. 3. 06	15. 2. 06	23 days	Guinea-pig dead of plague.
15	I. 12. 26 (M)	11. 3. 06	—	—	Plague rat found.
16	II. 11. 19 (N)	19. 3. 06	14. 2. 06	23 days	Guinea-pig dead of plague.

We became aware on the following day that a dead rat had been found, and although at this time we had no reasons for suspicion, yet as a matter of precaution two guinea-pigs were put into the building and on the following day were examined for fleas. One of them yielded 14 rat fleas and the other 10. The guinea-pigs were brought back to the laboratory for isolation but remained healthy.

On the 12th February two guinea-pigs were put into A but they could not afterwards be found. We had difficulty in obtaining the keys of these houses, and for this reason further experiments could not be carried out.

On the 27th March, that is towards the end of the experiment, the skeleton of a *Mus rattus* was found in some rubbish on the verandah of the building. It ought to be added that this building, compared with other buildings in the village, is built in a substantial manner.

House II. 13. 21 (B) (Plates XXIX, XXX).

The first cases of plague in the village occurred in this house. As we have already explained they came to our notice unexpectedly.

On the 5th February a girl aged 16 years, named Havloo Akar, a Sonkoli by caste, was attacked with plague. During her illness she was removed to camp and died there on 9th February. No examination was made during life on account of the concealment of the case, but the body was examined after death and a bubo was found in the left groin. The second case in this house was that of Raghunatu Lakshman, a boy seven years old, and a Maratha by caste. He also was attacked on the 5th February and died three days later. The body was examined after death and buboes were found on both sides of the neck.

The occupants of the house denied having found dead rats but a mummified rat was found by us on 11th February. This building immediately adjoins A on its south side. It has a very broken-down appearance, the outer walls being riddled with rat holes and one corner bulging outwards and showing large cracks, as if due to subsidence of the foundations.

The following experiments were carried out in the house :

(1) On the morning of the 9th February two guinea-pigs were allowed to run free in it and at 5 p.m. of the same day they were examined for the presence of fleas. On one 18 fleas were found and on the other five. These 23 fleas were removed to the laboratory and were transferred to a white rat in a flea-proof cage; this rat did not develop plague. The guinea-pigs were returned to the house and were examined next morning; one of them then yielded five fleas and the other 12. The guinea-pigs were then removed to the laboratory and segregated, but they remained healthy.

(2) On the 10th February four guinea-pigs were placed in the house. After 24 hours the first yielded 42 fleas: these were put on a guinea-pig in a flea-proof cage in the laboratory. This guinea-pig remained healthy but the guinea-pig which yielded the fleas for the cage experiment died of plague on the 13th February, after removal to the laboratory for isolation. The second and third guinea-pigs which

were put into the house yielded between them 37 fleas. These fleas were brought to the laboratory and were put along with a guinea-pig in a flea-proof cage; this guinea-pig, however, remained healthy as did also the animals which furnished the fleas for the experiment. The fourth guinea-pig which was put into the house could not be found.

(3) On the 13th February two guinea-pigs were introduced into the house. Next day 43 fleas were obtained from them. The fleas were removed to the laboratory in the evening and were put next morning on a guinea-pig in a flea-proof cage; this animal however was not attacked with plague. The guinea-pigs which furnished the fleas had disappeared on the 15th February.

(4) On the 15th February, two guinea-pigs were allowed to run free in the house. On the 18th they were put in a wire cage. Next day both were found to be sick and buboes could be felt in the neck. On the following day they were removed to the laboratory, where one of them, on which no fleas had been found before removal, died of plague on the 20th. The other, which furnished 12 fleas before removal, died of plague on the 21st.

Building II. 2, 3, 4 (C) (Plate XXIX).

It will be remembered that on the 28th January, the day on which they found the dead rat, the families in A took up their abode in this building. On the 9th February a man named Budhia Sukur, aged 40 years, and *belonging to the family originally living in the house C*, was attacked with plague. He was examined before death by the registrar of the district, Dr Bhatavadekar, who reported that the patient had a temperature of 102·5°, a dry and fevered tongue, injected conjunctivae, and that he was undoubtedly suffering from plague; there was a right femoral bubo. This man died on 11th February.

On 11th February a boy 16 years old, named Halia Bhiwa, was attacked with plague. He was a grandchild of Pasci and formerly lived with his mother in A. Dr Bhatavadekar examined him before death and found a right femoral bubo, with symptoms of high temperature, fevered tongue and injected eyes. In Dr Bhatavadekar's opinion the boy was suffering from plague. The boy died on the 13th February.

With regard to the source of infection of the cases in this building and in B, it is important to point out that the people in C were Christian Kolis, while those living in B were Hindu Kolis. It is certain that on account of this difference in caste these people had no connection with

each other. One is driven to conclude then that the common source of infection was the epizootic which probably originated in A.

It is possible to give several explanations of the method of infection in the case of the man and the boy living in C. It is conceivable, for example, that the rats in the house became infected in the course of the epizootic or from infected rat fleas introduced by the occupants of A in their belongings. Another possible explanation is that such infected fleas introduced into the building may have directly infected the persons who developed plague. Judging from the dates of attack of the cases in B and of those in this building the most probable explanation is the one given first, namely, that the infection was derived from the rats in the building, which had become plague infected in the course of the epizootic. In this connection it may be noted that Budhia Sukur was attacked several days before Pasci's grandchild.

The guinea-pig experiments in this building proved to be unsatisfactory. On the 12th February two guinea-pigs were placed in the building. Next day they yielded 10 rat fleas and 28 cat fleas. The rat fleas were removed to the laboratory and were put on a white rat in a flea-proof cage; the rat died in 10 days but the cause of death was not plague. On the 14th the guinea-pigs could not be found. On the same day they were replaced by two more guinea-pigs but next day these also had disappeared. No further experiments were carried out.

Building II. 22. 34 (D).

This building immediately adjoins A on its north side. The events connected with it which require notice are:

- (1) a positive guinea-pig experiment, and
- (2) a case of human plague.

Experiment: on the 12th February two guinea-pigs were put into the house. On the 17th one of them was noted to be sick: 18 fleas were secured on this guinea-pig and it was then brought to the laboratory for isolation, where it died of plague on the 19th. The other guinea-pig could not be found.

On the 14th February Maribai Amber, a woman 35 years old and a Christian Koli by caste, was attacked with plague; she died in a hut in the camp after an acute illness. The body was examined after death and a bubo was found in the right groin. This woman and the rest of the people living in the house vacated it on the 2nd February. There

can be little doubt, however, that she contracted the infection in this house, for the women of the camp were in the habit of visiting their houses in the village during the day time for purposes connected with their household duties, thus rendering themselves liable to the risk of infection.

House II. 25. 37 (E).

This house is owned by the "patel" (headman) of the village. It is situated in a row of buildings to the north of A. The incidents relating to this house which deserve notice may be summarised thus:

- (1) the discovery of a plague-infected rat in the house,
- (2) a positive guinea-pig experiment,
- (3) a case of plague whose infection was possibly contracted in the house.

(1) A strong smell of "dead rat" was noticed in the house on 17th February and on search a dead *Mus rattus* was found. Since on post-mortem examination it proved to be too putrid to permit of a diagnosis being made, the heart-blood and spleen were inoculated cutaneously on a guinea-pig, which subsequently died of plague.

(2) *Guinea-pig experiment*: on the 14th February two guinea-pigs were put into the house. On the 17th one was observed to be very sick; eight fleas were secured from it. It died shortly after removal to the laboratory and on dissection presented typical appearances of plague. The other guinea-pig appeared to be well. A third guinea-pig was placed in the house on the 17th, but of the two which now remained one was found partly eaten next day while no trace of the other could be discovered.

(3) On the 11th March a boy eight years old was attacked with plague. He lived with his uncle, the owner of this house, in a hut in the camp. A right femoral bubo developed and the boy died after a very acute illness. It is impossible in this case to state definitely the source of infection. We can only point out that the boy was in the habit of visiting this house with his aunt during the day time and it is possible that he derived the infection during one of these casual visits. We know at least that infection was present in the house three weeks previous to the date of his attack.

House II. 3. 5 (F) (Plate XXIX).

This house is situated directly opposite B, in which the first two plague cases occurred, and adjoins C which, as has already been described, also furnished two plague cases.

The following events connected with it require notice :

- (1) a positive guinea-pig experiment,
- (2) a case of plague whose infection was probably contracted in this house.

(1) *Guinea-pig experiment*: on the 12th February two guinea-pigs were placed in the house. On the 18th one was found dead and partly eaten; post-mortem examination showed typical appearances of plague. The other guinea-pig could not be found.

(2) On the 24th February Godibai Moti, a woman 40 years old and a Sonkoli (Hindu) by caste, was attacked with plague while living in the camp. We examined the patient and found that she had a high temperature, injected eyes, the typical speech of plague, and a right femoral bubo. She died on the 1st of March. Although she had been in the camp for 15 days there seems little room for doubt that she contracted the infection during a visit to this house for domestic purposes.

Building I. 5. 12, 13 (G 1 and G 2).

This building adjoins the south wall of the house just described and is separated from it by a narrow lane. The events which happened in it may be summarised thus :

- (1) discovery of plague-infected *Mus rattus*,
- (2) death from plague of two guinea-pigs in the house G 1,
- (3) death from plague of two guinea-pigs placed in the house G 2.

(1) On the 20th February a search was made in the house for rats and as a result a dead *Mus rattus* was found on the floor of one of the rooms of G 1. It yielded 12 cat fleas and 10 rat fleas. Examination proved that it was plague infected.

(2) On the 14th February two guinea-pigs were allowed to run free in the house G 1, and on the 18th they were put into a wire cage placed on the floor. On the 20th both were discovered to be sick. One of them had a submaxillary bubo and after removal to the laboratory for isolation died of plague on the 22nd. The second animal also had a bubo, and six cat fleas and three rat fleas were obtained from it. It was removed to the laboratory where it died of plague on the 21st.

On the 14th February two guinea-pigs were allowed to run free in the house G 2, and on the 18th they were transferred to a cage placed on the floor. On the 20th one was found dead of plague but no fleas were got on it. The other yielded two fleas; it was removed to the laboratory and died of plague on the 22nd February.

House I. 3. 9 (H).

This house occupies a position contiguous to G 2 and F. It furnished a successful guinea-pig experiment.

On the 13th February two guinea-pigs were allowed to run free in the house, and on the 18th they were confined in a wire cage. On the 20th one of them was sick and had a submaxillary bubo; two cat fleas and 12 rat fleas were secured from it. It was kept segregated in the laboratory and died of plague on the 22nd February. The other animal was thought to be somewhat sick and was therefore removed to the laboratory but it remained healthy. Six rat fleas and one cat flea were caught on it before removal.

House I. 7. 16 (I).

This house is not far distant from H but is somewhat nearer the southern limit of Koliwada. Attention may be directed to two events of interest connected with it, namely,

- (1) the discovery of a mummified rat in the house, and
- (2) a successful guinea-pig experiment.

(1) On the 21st February the characteristic rat odour was noticed; the house was therefore searched for rats but only the mummified remains of a *Mus rattus* were discovered.

(2) On the 15th February two guinea-pigs were allowed to run free in the house. They were kept confined in a wire cage after the 18th. On the 22nd one flea was caught on one of the guinea-pigs and a bubo was felt on the other. The latter animal yielded 8 fleas. It was removed to the laboratory and died of plague on the 24th February. On the 3rd March the remaining guinea-pig was found dead of plague.

House I. 9. 19 (K).

This house is a building which is situated immediately to the south of the one just described. The occupants vacated it in order to go into camp on the 12th February, but we were unable to use the house for an experiment for several weeks because the key was not available. The following events of interest occurred in connection with this house :

- (1) the discovery of a plague-infected *Mus rattus*,
- (2) a laboratory experiment with fleas obtained from this rat,
- (3) an experiment with guinea-pigs in specially constructed cages placed within the house.

(1) On the evening of the 28th February an adult *Mus rattus* was captured and killed, as it was coming out of an opening in the wall intended for the exit of waste water. Post-mortem examination proved the rat to have typical septicaemic plague, cultures of *B. pestis* being obtained from the heart-blood, spleen and liver. Immediately after its capture 12 rat fleas were secured from it.

(2) These fleas were at once brought to the laboratory and, after being fed on a shaved area of the abdomen of a guinea-pig, were put with it into a flea-proof cage. The guinea-pig, however, did not develop plague.

(3) On the 1st of March the whole of the building was searched in a thorough manner, but no dead rats were found. On this date also two guinea-pigs were put into the house, one in a cage with wire gauze curtains affording protection of the inmate against fleas and the other in a similar cage but without this protection. The cages were kept in the house for 11 days and the guinea-pigs were then removed and isolated, but they both remained healthy. Although frequent examinations of the animals were made during their sojourn in the house on no occasion were any fleas found upon them.

House I. 12. 26 (L).

This is a small house situated quite near the last and only a short distance from the southern boundary of the village (Koliwada). The events which occurred in connection with it are of particular interest and importance in their relation to the entire experiment. We propose to deal with them under three headings :

- I. An account of the dead rats found in the house.
- II. The routine guinea-pig experiment carried out in the house.
- III. An account of special experiments which were carried out.

I. An account of the dead rats found in the house.

On the 11th March during a thorough search in the house for dead rats an adult *Mus rattus* showing signs of putrefaction was found. No fleas were captured on it. It had a right axillary bubo, containing swarms of plague bacilli including involution forms, and in addition many *B. pestis* were found in the spleen and heart-blood. Next day a dead *Mus rattus* was found on the floor near the door: 25 rat fleas were caught on it. This rat had a right submaxillary bubo and a culture of *B. pestis* was obtained from the heart-blood. On the following day a dead *Mus rattus* was found under a pile of firewood. It was very

maggoty so that it was impossible to make anything out of the post-mortem appearances, but a few plague-like bacilli were seen in the spleen smear together with many putrefactive bacilli, and many plague-like bacilli were seen in a preparation of the heart-blood.

II. *The routine guinea-pig experiment.*

On the 15th February two guinea-pigs were put into the house. On the 16th March, *i.e.* a month later, one of the guinea-pigs showed a submaxillary bubo. At least five fleas were seen on this animal and three or four on the other. Two days later one of the guinea-pigs was found dead and eight fleas were secured from it. Examination revealed deep cervical buboes and other typical appearances of plague. The second guinea-pig yielded 26 fleas; these were put back into the house. This animal was brought to the laboratory for segregation and died on the 22nd March, the post-mortem showing neck buboes and other signs of plague. It is interesting to note that this guinea-pig during life had a small phlyctenule in the submaxillary region. It is noteworthy that in this house a plague rat was found five days before the guinea-pigs showed signs of illness.

III. *Special experiments carried out in connection with this house.*

I. On the 12th March the following animals were placed in the house:

(1) A monkey in a cage protected from fleas with fine wire gauze, and a monkey in a similar cage without gauze.

(2) A white rat in a tanglefoot cage, and a white rat in a similar cage without tanglefoot.

All these animals were kept in the house for two days and were then brought to the laboratory for isolation.

Three fleas were got on the unprotected monkey. No fleas were obtained before removal on the rat in the tanglefoot cage but seven fleas were got on the tanglefoot. It was found on dissection of these fleas that five of them contained bacilli in their stomachs resembling *B. pestis*. On the control rat two fleas were caught, one of which was found to contain similar bacilli. Both rats, however, remained healthy. Both monkeys, also, remained perfectly healthy.

II. 25 fleas captured on the rat which was found in the house on the 12th March and which was proved to be plague infected, were brought to the laboratory and put on a guinea-pig in a flea-proof cage. This guinea-pig died in four days with typical appearances of plague,

including cervical and submaxillary buboes on both sides. Cultures of *B. pestis* were obtained from its heart-blood.

House I. 13. 27 (M).

This house is interesting as being the one furthest from the original focus A which gave evidence of containing plague infection. It immediately adjoins L and is situated within a few yards of the row of houses constituting the southern boundary of the portion of the village known as Koliwada.

The observations and experiments made in it may be arranged in a manner similar to those described in connection with the last house.

I. *An account of the dead rats found in the house.*

On the 17th March a fresh *Mus rattus* was found dead on the floor of an inner room and five fleas were removed from it. The rat showed right and left pelvic buboes and other typical appearances of plague and a culture of *B. pestis* was obtained from the heart-blood. At the same time a mummified *Mus rattus* was found in the same place but was too decomposed to permit of a diagnosis. On the next day a mummified rat was discovered in a loft in an inner room. On the 22nd a dead rat was found in the same room; one flea captured on it was put back in the room. This rat was crawling with maggots but a smear from the liver showed a few typical plague bacilli. A mummified rat was found here at the same time. The search for these rats was suggested partly by the characteristic odour caused by them. On the 24th March a dead mouse was found in front of the house; the organs were somewhat putrid and did not suggest plague infection. On the 27th March a dead adult *Mus rattus* was found in a back room; eight fleas were caught on it but they were put back into the room. This rat proved to be plague infected.

II. *The routine guinea-pig experiment.*

On the 15th February two guinea-pigs were allowed to run free in the house and three days later they were confined in a wire cage. Fleas were observed on the animals on several occasions but they remained healthy for nearly a month. On the 11th of March one of them was found dead; no fleas were seen on it but dissection revealed typical appearances of plague. On the 4th April the other guinea-pig was found to have a bubo and to be sick; it yielded four fleas. After being brought to the laboratory it was killed and found to have a left inguinal bubo and other typical signs of plague.

III. *Special experiments carried out in the house.*

On the 17th March the following animals were put into the house:

(1) Two monkeys, one in a cage with wire gauze and the other in a similar cage but without this protection.

(2) Two guinea-pigs, one in a wire gauze cage and the other in a similar cage without gauze.

(3) Two white rats, one in a tanglefoot cage and the other in a similar cage without tanglefoot.

The animals were kept in the house for five days and were then brought to the laboratory and segregated. No fleas were found on any of these animals.

The unprotected rat died of plague on the 29th March and when examined was found to have double submaxillary buboes with subcutaneous congestion and pleural effusion. As the abdominal organs were somewhat putrid the liver and spleen were inoculated cutaneously into a guinea-pig, which died in four days with typical signs of plague, a culture of *B. pestis* being obtained from the heart-blood and liver.

The other five experimental animals remained healthy. Six fleas were found in the tanglefoot on the cage of the control rat; three were cat fleas, two were rat fleas, and one was a human flea, but on dissection none were found to contain plague-like bacilli.

House II. 11. 19 (N).

This is the last house which calls for special description, but the events which happened in it are somewhat difficult of explanation. The house is situated within a short distance of A and adjoins a building in which a guinea-pig died of plague as early as the 17th February.

On the 12th February two guinea-pigs were put into N. Next day 15 fleas were secured from one of them; the fleas were brought to the laboratory. Whether the removal of these fleas affected in any way the course of events it is impossible to say, but it is certainly curious that the guinea-pigs and two more which were added on the 14th February remained perfectly healthy till five weeks later.

On the 19th March one of the guinea-pigs was found dead. Examination showed that death was due to plague. Next day the house was searched thoroughly for dead rats but none were found. Two days later a guinea-pig which was in the same cage as the one which was found dead was found to have a submaxillary bubo and to be sick. Only one flea could be obtained from it. The animal was removed to

the laboratory where it died next day. It was found to present the usual appearances of plague.

No fleas were seen on the two remaining guinea-pigs, and although the house was searched thoroughly for dead rats on several occasions none were found.

It is extremely difficult to arrive at any conclusion as to the source of infection of the guinea-pigs which died. There is no evidence that they were infected from plague rats in the house, although it is of course possible that a plague rat may have died among the tiles of the roof and the fleas from it dropped into the room below. The other two guinea-pigs remained healthy till the end of the experiment.

4. *Details concerning the guinea-pigs which died from plague infection received in the houses.* (Table I.)

Out of 51¹ guinea-pigs placed in the houses 36 died of plague (70%) while 15 survived. Forty¹ guinea-pigs were put in houses which proved to be plague infected and of these only four remained healthy, *i.e.* 90% died of plague. Two of these four animals were removed to the laboratory no doubt prematurely with sick companions which subsequently died of plague. The remaining two are those which survived in N.

Of 27 buildings (out of a total of 51 in the village) into which guinea-pigs were put, 21 were proved to be infected by the death of the guinea-pigs from plague: six buildings remained apparently free from infection.

With regard to the number of rat fleas found on the guinea-pigs which died of plague, the results depended entirely on whether the guinea-pig was found to be sick or was found dead. Twelve guinea-pigs were found dead. On 11 of these no fleas were obtained, on the remaining one eight fleas were caught. The largest number of rat fleas caught on a sick guinea-pig was 89, the average number for the sick animals being about 15. We may recall the fact that 24 fleas were caught on the two guinea-pigs which were placed in A. This relatively high count, which, as we shall show later, is characteristic of the infected houses in Koliwada compared with the non-infected houses, strengthens the probability that the dead rat found in A was plague infected. (See vol. VII. p. 445.) It is necessary to point out in this

¹ In this computation no account is taken of guinea-pigs which were lost or were killed by cats, nor do these figures include the guinea-pigs in the special experiments carried out in L and M.

connection that we have had instances of animals escaping infection during a stay in a plague house although fleas obtained on them gave plague when transferred to an animal in the laboratory.

Only twelve cat fleas were captured on all the guinea-pigs placed in the houses although the houses were swarming with cat fleas, as we knew to our cost when we entered them. It is evident, then, that cat fleas have no great liking for the guinea-pig or that they do not remain so long in its fur as the rat flea does.

With reference to the distribution of the buboes in the guinea-pigs dead of plague it will be noted (see Table I) that the overwhelming majority were in the region of the neck. Buboes rarely occurred in the inguinal region and not once in the axilla.

5. *Details concerning the dead rats found in Sion Koliwada.*
(Maps V and VI.) (Table IV.)

A remarkable feature in our study of plague in this village is the small number of dead rats found. Without doubt at the beginning of the epizootic, partly because some of the houses were occupied and partly on account of the prejudices of the people in the matter of disturbing their household belongings, the search for dead rats was not as thorough as it might have been.

Later when the houses were more under our control and when we were in a position better to appreciate the course of events as regards plague infection in the houses, a very thorough search was made with consequently more satisfactory results.

Still it must be admitted that, considering the severity of the epidemic, the number of plague rats found is very small, although it is amply sufficient to show that an epizootic existed amongst the rats during the period of the experiment. Our experience in this connection affords an excellent illustration of the danger which observers of plague epidemics may incur of concluding that plague rats are absent from an infected locality when a thorough search has not been made.

Again it will be seen from the Table III and Maps V and VI that the course taken by the epizootic corresponds generally both in time and place with that taken by the epidemic amongst the guinea-pigs.

The fact that on very few occasions a plague rat was found before the death of the inmate of the house (whether human or animal) is sufficiently explained by the difficulties met with in the search for rats.

TABLE IV.

Giving details of rats found in Sion Koliwada, arranged in order of date when found.

Serial No.	House No.	Date when found	Fleas caught on rat	Bubo	Remarks
1	II. 18. 27 (A)	28. 1. 06	—	—	History of dead rat thrown out.
2	II. 13. 21 (B)	11. 2. 06	—	—	Mummified.
3	II. 25. 37 (E)	17. 2. 06	0	—	Putrid; guinea-pig inoculated cutaneously died of plague.
4	I. 5. 12 (G 1)	20. 2. 06	12 cat fleas 10 rat fleas	Submax.	Cultures from heart-blood, spleen and liver.
5	I. 7. 16 (I)	21. 2. 06	—	—	Mummified.
6	I. 9. 19 (K)	28. 2. 06	12	None	Cultures of <i>B. pestis</i> from heart-blood, spleen and liver.
7	I. 12. 26 (L)	11. 3. 06	0	Right axillary	Putrid; many <i>B. pestis</i> in organs with invol. forms in bubo.
		12. 3. 06	24	Right submax.	Cultures from heart-blood.
		13. 3. 06	0	—	Very maggoty; spleen, a few <i>B. pestis</i> like, many putrefact. organisms. Heart-blood, many <i>B. pestis</i> like, many putrefactive organisms.
8	I. 13. 27 (M)	17. 3. 06	5	Retroperitoneal	Culture of <i>B. pestis</i> from heart-blood.
		17. 3. 06	0	—	Mummified.
		18. 3. 06	—	—	”
		22. 3. 06	1	—	Maggoty; a few typical <i>B. pestis</i> in liver.
		22. 3. 06	—	—	Mummified.
		24. 3. 06	—	—	Mouse, plague?
9	Near II. 1. 1 and 2	24. 3. 06	—	—	Typ. p.m. subcut. haemorrh. Numerous <i>B. pestis</i> in heart-blood, spleen, bubo.
		27. 3. 06	8	Left axillary	
		27. 3. 06	—	—	Mummified.
10	II. 18. 28 (A)	27. 3. 06	—	—	Skeleton of <i>rattus</i> .

It is not easy to give a full explanation of the reasons for the spread of the epizootic from house to house, though it is certain that the rats in this village have not the slightest difficulty in communicating freely with their neighbours in adjoining houses.

An interesting point in connection with the rat epizootic concerns the length of time the infection persisted amongst the rats. We may conveniently consider this aspect of the epizootic under three headings:

(1) The duration of the infection amongst the rats within the village: if we regard the rat thrown out of A as a plague rat—and we

think this is a justifiable assumption—the length of time between the discovery of this rat and the last plague rat in the village is almost exactly two months.

(2) The rate of diffusion of the infection in the rat population: the infection took at least six weeks to travel from A to M, *i.e.* a distance of only about 300 feet.

(3) The duration of the infection amongst the rats within a house: house M probably gives a fairly correct idea of the length of time infection may persist in the rats in a house, *when no reinfection takes place from outside*. The order of events in the epizootic leading up to the infection of this house is such that reinfection is not likely to have happened. The first plague rat found was on the 17th March and the last on the 27th, that is, the infection persisted in the rats for at least ten days.

A point of considerable importance is that without exception every dead rat found belonged to the species *M. rattus*. It has already been mentioned that no drains or gullies exist in the village. This doubtless accounts for the absence of *M. decumanus* in the village. In the rat collection made throughout the year this species has never once been found.

The buboes in the rats diagnosed as plague were distributed as follows: two submaxillary, two axillary, one pelvic, and in one rat there was no bubo.

6. *Remarks on the houses occupied by men or by guinea-pigs which failed to show evidence of plague infection.* (Map V.)

The most important point to note is that the last three houses in the village, *viz.* those constituting its southern boundary, remained so far as we could discover free from infection. Building I. 14, which closely adjoins the last infected house of all, namely M, in which three rats proved to be plague infected were found, was frequently searched in a very thorough manner but no dead rats were ever found in it. It would seem then that the epizootic had died out in M about 27th March¹. No other explanation than that it came to a natural end in this house can be brought forward, for there is nothing in the construction of these adjacent houses which differs in any essential respect from that of the plague-infected houses. Two reasons

¹ As will however be seen below, a plague-infected rat was found in Bhandarwada on March 30, 120 feet from house M. (See Map V.)

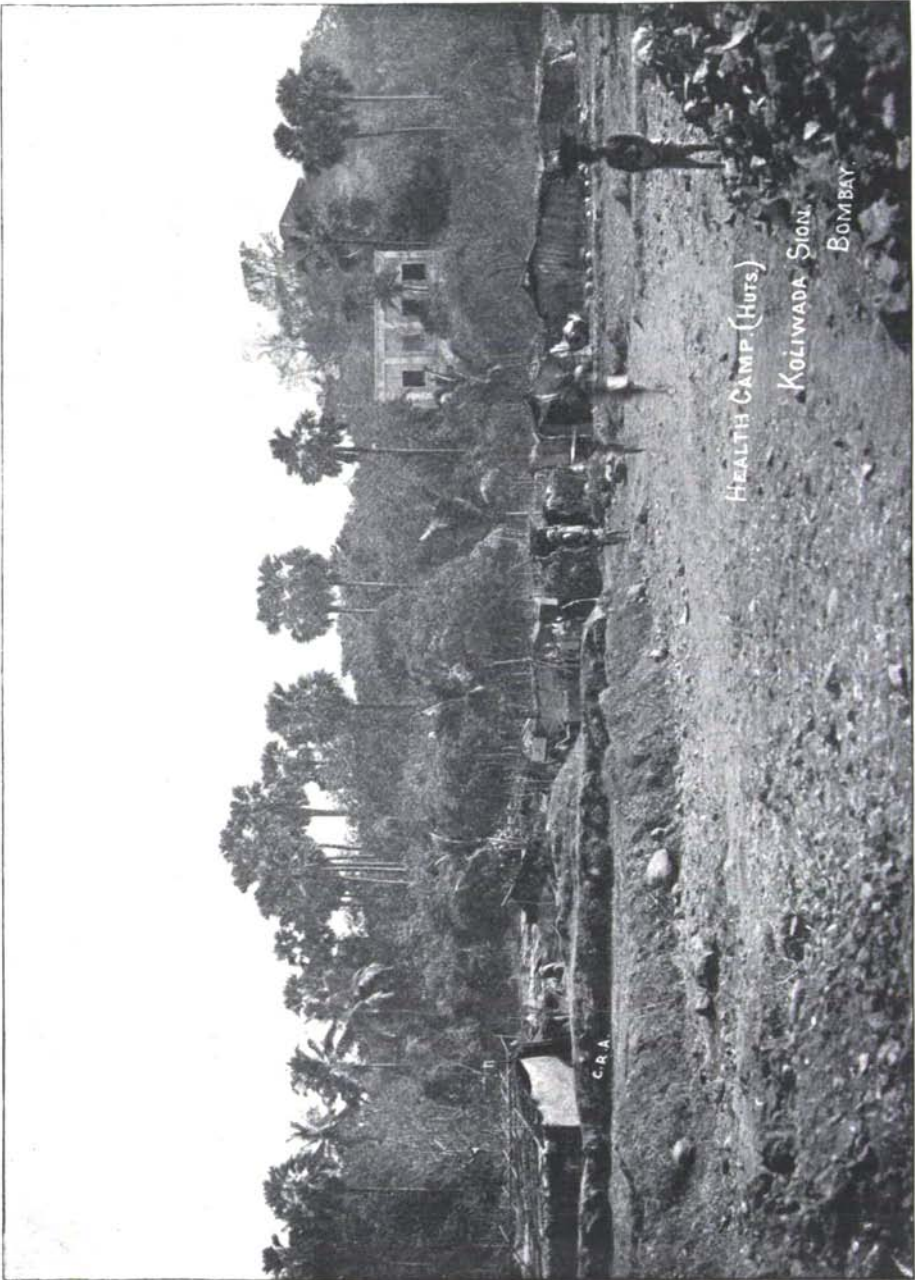
for the cessation of the epizootic at this time (the end of March) may be given. It may be ascribed to an accidental break in its continuity from house to house, infected rats in M failing to come into proximity to the rats in next door. Or the epizootic may have been brought to an end by influences which determine the seasonal prevalence of plague. We believe the latter explanation to be the more probable one, because the epizootic in the City of Bombay about this time began to show marked signs of diminishing.

Besides the houses with guinea-pigs which remained free of plague infection, certain others deserve mention: namely I. 4. 10, II. 10. 17, 18, and II. 20. 31. They were occupied by their inhabitants throughout, and the people, although apparently taking a risk, suffered no harm. In this connection we may state an impression which was forced upon us by our experiences in this village, namely, that the guinea-pig is a more sensitive indicator of plague infection in a house than its human occupants. We are disposed to attribute this to the readiness with which rat fleas live upon guinea-pigs, a question which is dealt with in another paper.

7. *A description of the camp.* (Plates XXXII, XXXIII.)

During the period of the experiment, *i.e.* from the 12th February to the 16th April, the villagers took up their residence in a camp of huts situated only a few hundred yards from the village. Strict observation was kept during this time to ascertain whether any indigenous cases of plague might arise. It is almost certain that none such occurred. One or two cases were indeed found in the camp but these, as we have already pointed out, most probably derived their infection from visits made to infected houses in the village. We had not the slightest reason to suppose that there were any plague rats in the camp. Indeed, so far as we could discover there were no rats in the huts, probably because their construction was so simple and crude that they afforded no shelter for rats. The huts were built of the simplest materials. One, which will serve as an example (Plate XXXIII), was composed of gunny-bag sacking, palm leaves, matting, tatties (bamboo chips), kerosene oil tins, corrugated sheets, planking and bamboo poles.

It only remains to state that the villagers began to break up their camp and to return to the village on the 16th April, a fortnight to three weeks after the discovery of the last plague-infected rat. They acted in this matter, as in their decision to evacuate the village, entirely on



Sion Koliwada: Health Camp, general view.



Sion Koliwada: a hut in Health Camp.

their own initiative, though their choice of this particular day was dictated to a large extent by certain superstitious beliefs. After their return no case of plague occurred in Koliwada.

Before concluding this account of the Koliwada experiment it is necessary to draw attention to its bearing upon the observations made during the earlier period. Briefly, it may be said that the facts related in the foregoing pages seem to us to furnish strong reasons for believing that an epizootic existed in the earlier period and that the dead rat found in A on the 28th January represents the first evidence of plague infection in the village.

Section C. *Observations made in Agriwada¹ and Bhandarwada.*
(Maps V and VII. Tables III and IV.)

A. *Introductory.* It ought to be pointed out that during the time in which the experiment was progressing in Koliwada the inhabitants of the rest of the village of Sion still occupied their houses. As at one time it appeared probable that the infection might spread from Koliwada into Bhandarwada, on the 21st February a guinea-pig in a wire cage was put into each of four houses in Bhandarwada immediately adjoining Koliwada. Two days later a guinea-pig was put into each of the remaining houses in Bhandarwada, and on the 2nd March this was also done in the case of Agriwada.

We may anticipate so far as to say that very little infection occurred amongst these guinea-pigs. However, a small but interesting outbreak was observed in several houses and this we shall proceed to

TABLE V.

Table of plague rats found in Agriwada and Bhandarwada.

Serial No.	House No.	Date when found	Fleas caught on rat	Bubo	Remarks
11	Agriwada 47. 67	23. 2. 06	At least 1 seen	None	Culture of <i>B. pestis</i> from heart-blood and liver.
		5. 3. 06	81	Left axillary	Culture of <i>B. pestis</i> from heart-blood.
		5. 3. 06	12	Left submax.	Culture of <i>B. pestis</i> from heart-blood.
		6. 3. 06	3	Retroperitoneal	Culture of <i>B. pestis</i> from heart-blood and liver.
		8. 3. 06	35	None	Culture of <i>B. pestis</i> from heart-blood and liver.
12	Near 37. 67 Bhandarwada	30. 3. 06	—	Right submax.	Typ. p.m. Very numerous <i>B. pestis</i> in heart-blood, spleen bubo.

¹ Spelt "Agarvada" on map.

describe. The house of principal interest is the one in which the epizootic originated, viz. **47. 67** Agriwada (House P: Map VII).

TABLE VI.

Table of guinea-pigs which died of plague in Agriwada and Bhandarwada.

Serial No.	House No.	Date when guinea-pig was put in	Date of death	No. of fleason dead guinea-pig, or before removal to laboratory	Bubo	Remarks
23	Agriwada 47. 67	28. 2. 06	5. 3. 06	1	Right and left inguinal and retroperitoneal	—
		28. 2. 06	24. 3. 06	4	Submax.	Chloroformed to death. Chronic plague.
24	Agriwada 3165	2. 3. 06	26. 3. 06	6	„	Chloroformed to death. 3 sub-maxillary phlyctenules.
25	Agriwada 27. 36	2. 3. 06	1. 4. 06	0	„	—
26	Bhandarwada 5. 19	23. 2. 06	2. 4. 06	4	„	Phlyctenule on lowerlip. Chloroformed to death.
27	Bhandarwada 30. 55	23. 2. 06	30. 4. 06	0	Right inguinal	—

B. *Events relating to certain plague-infected houses.*

House 47. 67 (P) Agriwada. (Plate XXXI.)

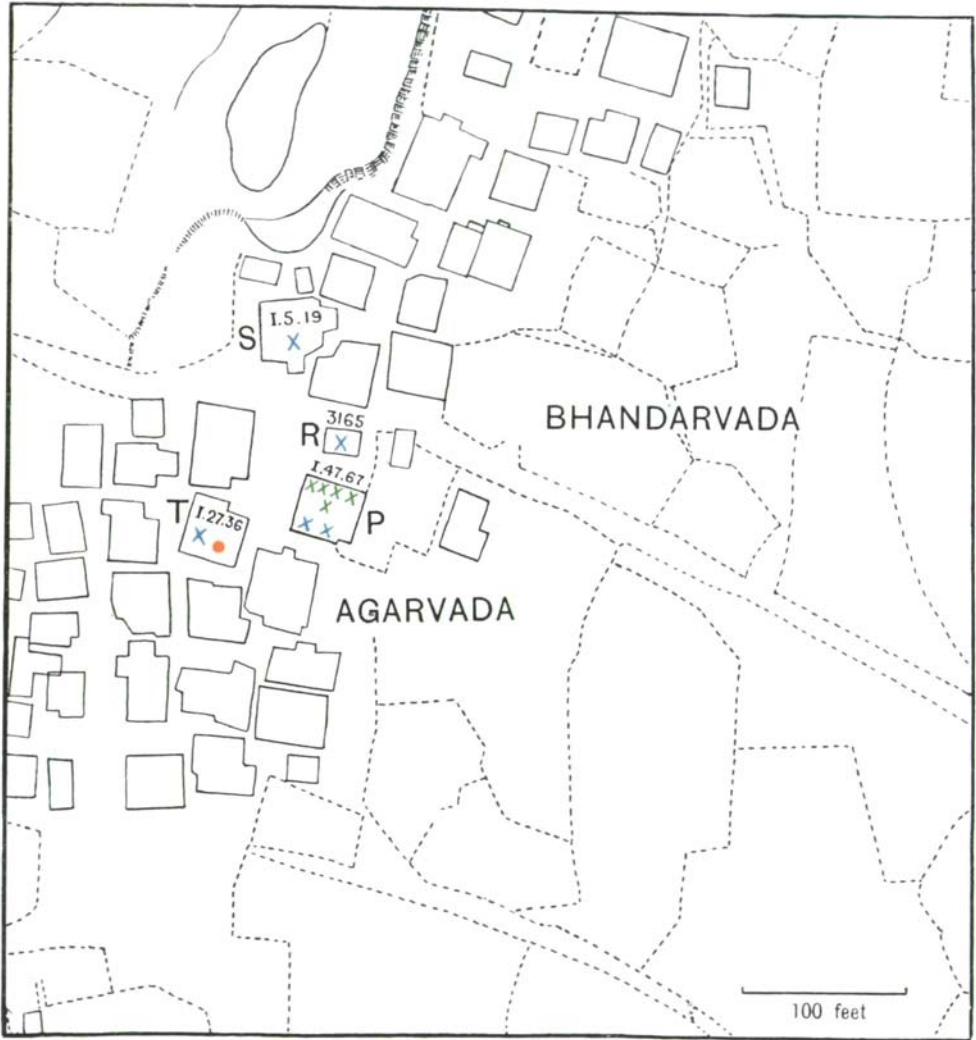
On the 23rd February the occupants found a dead rat in the house. It was handed over to us and on examination proved to be plague infected, cultures of *B. pestis* being obtained from the heart-blood and liver. The occupants of the house are vegetable sellers; they buy vegetables in the city, bring them to the house and sell them in the neighbouring districts. We may state at once that we could find no definite clue to the source of the infection.

On the following day the people vacated the house with the exception of an old man, who, however, slept on the verandah outside.

The events of importance which occurred in the house may be conveniently arranged into three groups:

- I. An account of the dead rats found in the house.
- II. The fate of the guinea-pigs placed in ordinary wire cages.
- III. Special experiments.

MAP VII



SION VILLAGE

- Human case of plague
- × Guinea-pig dead of plague
- × Plague infected rat

I. *Rats.* Mention has already been made of the plague rat (a *Mus rattus*) found on the 23rd February. On the 5th March a dead *Mus rattus* was found in the house: 12 fleas were captured on it and examination proved it to be plague infected, a submaxillary bubo being present and a culture being obtained from the heart-blood. Search revealed a second dead rat lying on the floor in an inner room. This rat yielded 81 fleas. All the fleas were returned to the house. A left axillary bubo was present and a culture of *B. pestis* was obtained from the heart-blood.

Next day a thorough search was made through the whole house, with the result that another dead rat was found in an inner room with part of the head and neck eaten; three fleas were obtained from it. Retroperitoneal buboes were found on post-mortem examination and a culture was obtained from the heart-blood and liver. The house was found to be rat riddled and there was a strong smell of dead rats. Two days later a dead rat was found on the floor of one of the rooms: 35 fleas were caught on it and these were returned to the room. There was no primary bubo but the appearances were typical of plague and cultures were obtained from the heart-blood and liver. A daily search was made for rats subsequently, but none were found. In this house the infection apparently persisted in the rats for 13 days. All the rats found were *Mus rattus*.

II. *The fate of the guinea-pigs.* On the 28th February two guinea-pigs were put into a wire cage in the house. On the 5th March one of them was found dead, and one flea was caught on it. The post-mortem examination revealed typical signs of plague, double inguinal and pelvic buboes being present. On the 19th March the remaining guinea-pig was observed to have a right submaxillary bubo and two rat fleas and two cat fleas were found on it. It was removed to the laboratory where it was chloroformed to death; the post-mortem examination showed that it had a relatively chronic form of plague.

III. *Special experiments.* The following animals were placed in the house in specially constructed cages:

- I. On the 5th March two monkeys, one in a tanglefoot cage the other in a control cage.
- II. On the 5th March two guinea-pigs, one in a wire gauze cage the other in a control cage.
- III. On the 8th March two white rats, one in a tanglefoot cage the other in a control cage.

IV. On the 7th March two guinea-pigs, one in a tanglefoot cage the other in a control cage.

V. On the 9th March two white rats, one in a wire gauze cage the other in a control cage.

I. *Experiment with monkeys.* It has been already stated that 93 fleas were captured from two dead plague-infected rats on the 5th March, and that they were returned to the house. On this date two monkeys were put into the house, one in a tanglefoot cage and the other in a similar cage without tanglefoot. Two days later the tanglefoot cage was examined and 24 fleas (not identified) were obtained on the tanglefoot; 16 of these were dissected but none were found infected. On the 9th both monkeys were examined for fleas; two were found on the non-tanglefoot animal, none on the other. The monkey in the cage without tanglefoot died on the 12th March. A left axillary bubo and abundant pleural effusion were present. Numerous bacilli were seen in the organs, and cultures were obtained from the heart-blood, liver and spleen; the cultures inoculated into rats killed them with typical appearances of plague. The monkey which was protected from fleas by the tanglefoot remained healthy.

II. *Experiment with guinea-pigs.* On the 5th March two guinea-pigs were placed in the house, one in a cage provided with a wire gauze curtain and the other in a similar cage without this protection. On the 9th the animal in the unprotected cage was observed to be sick with a bubo in the neck; three fleas were secured from it. It was brought back to the laboratory and died there shortly afterwards, post-mortem examination revealing typical signs of plague with cervical buboes; a culture of *B. pestis* was obtained from the heart-blood. The animal which was protected from fleas remained healthy.

III. *Experiment with white rats.* On the 8th March two white rats were put into the house, one in a tanglefoot cage and the other in a similar cage without tanglefoot. Next day 16 fleas were obtained on the tanglefoot but none on the rat itself. On the 10th two fleas were got on the rat in the tanglefoot cage, but it must be noted that the tanglefoot paper was only 2 to 2½ inches broad. Next day both rats were removed from the house and kept isolated. The rat in the tanglefoot cage remained healthy. On the control rat before removal 13 fleas were captured, four of these being cat fleas. This rat was found dead on the 13th March. Right inguinal and right axillary buboes were present, numerous plague bacilli were present in the spleen and bubo, and cultures of *B. pestis* were obtained from the heart-

blood and liver. The 15 fleas which were obtained from the two rats before removal from the house were transferred to a guinea-pig in a flea-proof cage but the animal remained healthy.

IV. *Second experiment with guinea-pigs.* On the 7th March two guinea-pigs were put into the house, one in a cage with tanglefoot and the other without this. The details of this experiment need not be given since both guinea-pigs remained healthy.

V. *Second experiment with white rats.* On the 9th March two white rats were put into the house, one in a cage protected with fine meshed wire gauze and the other in a similar cage without gauze. Both animals remained healthy.

House R 3165 Agriwada.

As will be seen from the map (VII) this is a small house closely adjoining the last. On the 16th March it was found to be vacated. The woman who occupied it admitted that she found a dead rat on the floor and that she threw it out. Although this house was thoroughly searched for rats on several occasions none were found.

However, on the 24th March the guinea-pig which had been placed in the house was observed to be sick. Next day three small phlyctenules were noticed on the right side of the neck and a bubo was felt here. The phlyctenules resembled vaccination vesicles, each being surrounded by a zone of redness and being situated in the centre of a small hairless patch of skin; they were exactly like the vesicles seen when plague material is rubbed into the skin of a guinea-pig or like those seen occasionally on guinea-pigs experimentally infected by fleas. Six fleas were removed from the guinea-pig which was then brought back to the laboratory, where next day it was chloroformed to death, post-mortem examination showing submaxillary buboes and other typical appearances of plague.

House 5. 19 (S) Bhandarwada.

This house is situated only a few yards from the last. On the 2nd April the guinea-pig in the house was found to be sick with a phlyctenule on the lower lip and a right submaxillary bubo; four fleas were found on it. It was removed to the laboratory where it was chloroformed to death, examination revealing submaxillary and cervical buboes and other signs of plague. No rats were found on search in the house. The occupants vacated the house for about a week and then returned to it.

House 27. 36 (T) Agriwada.

This house closely adjoins house P. On the 1st April the guinea-pig in the house was found dead. No fleas were recovered from it but on examination it proved to be plague infected.

Next day a plague case in this house was reported to us. The patient was a young man, 17 years old and by occupation a bookbinder in Bombay City. He stated that he came home from work on the evening of the 31st March feeling ill and feverish. The case was undoubtedly one of plague, a right femoral bubo being present. The patient died on the 6th March and the house was then vacated. It was searched thoroughly for dead rats but none were found. The question of the source of infection in this case is a difficult one. There was a clear history of dead rats in the office in which the man worked, and in fact about the same time a case of plague in the adjoining village of Wadhala came to our notice, in which the source of infection appeared to be the same office. An alternative explanation is that the case we are considering became infected from rats in the house which in turn owed their infection to the epizootic in house P. This view naturally receives support from the circumstance that the guinea-pig in the house died of plague, as we have described.

There can be no doubt that a limited epizootic had broken out in this quarter of Agriwada. It may at first sight seem strange that considering the severity of the infection in house P the outbreak did not extend further than it did. According to our view the most feasible explanation is the one we have already given when discussing the cessation of the epizootic in Koliwada, namely, that influences determining the seasonal decline of the epizootic had begun to take effect.

Two incidents remain to be noticed which happened in Bhandarwada.

(1) On the 30th March a rat was captured near **37. 67**, 120 feet south-west of house M in Koliwada. (See Map V.) It proved to be plague infected, a right submaxillary bubo being present. As this rat was caught only three days after a plague rat was found in house M Koliwada it may be that it represents the last trace of the Koliwada epizootic.

(2) The second occurrence is that on 30th April a guinea-pig was found dead in a house (marked O in Map V) 100 feet further south. It was found to have died of plague. The occupants continued to live in the house but nothing further happened and we could obtain no

clue as to the source of infection of this animal. This is the last event which pointed to the presence of plague infection in the village. As the guinea-pigs in all the other houses remained healthy they were removed to the laboratory on the 30th May.

Section D. *General survey of plague in Sion Village.*

It has been explained that our original intention was to make as complete a study as possible of the outbreak of rat and human plague which was expected to occur in the village of Sion, giving particular attention to the origin of the epizootic and of the epidemic.

We have described how our efforts in this direction were not as successful as we hoped, on account of the concealment of the epizootic at the commencement and of the first human cases. The available evidence, however, inclines strongly to show that the infection in Koliwada was not of indigenous origin but was imported, as it were by a mere chance, from Bombay City, having being brought by a woman who resided in an infected quarter of the city.

It is impossible to state exactly in what form the infection was brought to the village. With our present knowledge we can recognise only two media capable of conveying infection from one place to another, namely, either infected rats or infected fleas. In the case of Koliwada the latter is the more probable explanation of the two. It is obvious, however, that infection transported by infected rat fleas must remain, except under experimental conditions, incapable of proof.

Whatever may have been its origin an epizootic undoubtedly broke out amongst the rats inhabiting the houses, the infection spreading gradually amongst them throughout the village.

Taking advantage of the voluntary evacuation of the village (Koliwada) by its inhabitants, it was decided to substitute in as many of the houses as possible a guinea-pig population. As the subsequent course of events showed this procedure proved ideal for studying the problem of the relation of the epizootic to the infectivity of houses. The epidemic was entirely under our control for purposes of observation—much more so than any human epidemic could ever be. Thus it was possible frequently to note the number of fleas on the guinea-pigs and to make a complete diagnosis of every guinea-pig which died. Moreover, the outstanding advantage of the scheme was that the guinea-pigs in separate buildings were kept isolated from each other, so that there

could be no question in any instance of infection having been conveyed by direct contact with a sick animal.

It has been shown that corresponding to the epizootic amongst the rats many of the houses became infective, the proof of this being that in the early period of the epizootic several human cases occurred and that at a later period most of the guinea-pigs which were placed in the houses died of plague.

The association of the epizootic with the epidemic. It is apparent from a review of the facts that the guinea-pig epidemic in Koliwada was closely related to the outbreak amongst the rats. Thus, it has been shown that the "epidemic" followed a fairly definite course, extending gradually from the houses in the vicinity of the original focus, till it reached the two houses near the southern limit of this quarter of the village, which were proved to be badly plague infected. The rat epizootic was roughly coextensive with the epidemic, and coincided with it in point of time. Moreover, in the two houses mentioned and in 47. 67 (P) Agriwada the number of plague rats found corresponded to the degree of infectivity of the houses, as judged by the success of the experiments carried out in them. Again, in several instances the experimental animals in the houses remained healthy until plague-infected rats were found. The fact that plague rats were not found first in all the houses is doubtless due to difficulties to which we have already alluded.

The mode of infection of the human cases and the guinea-pigs. With regard to the mode of infection of the human cases and of the guinea-pigs, it is certain that the source of infection was common to all.

The possibility of direct infection, *e.g.* by infected excreta from a human case in one building to a case in the other or from a guinea-pig in one building to a guinea-pig in another, is absolutely excluded. In the first instance the human occupants of the infected buildings had no relations with each other on account of differences in caste, and in the case of the guinea-pigs it is evident that such a mode of infection was rendered impossible by their isolation in the houses.

The hypothesis that the common source of infection was a soil infection is in the highest degree improbable. We have proved experimentally that nothing short of gross contamination of soil with plague bacilli is capable of causing infection to guinea-pigs and that only a small percentage of guinea-pigs exposed to such infection develop plague.

It may be noted, also, that the distribution of the buboes in the

guinea-pigs infected experimentally in this way does not correspond with the distribution in the guinea-pigs which received their infection in the houses of Koliwada. Moreover, the animals which became infected in the cages of special construction were protected from any possible risk of soil infection.

We may, now, gather together the facts which are in favour of the view that the infection was brought about by the intermediary of infected rat fleas:

(a) All the houses which proved to be infective contained rat fleas, and rat fleas in considerable numbers were readily captured on the guinea-pigs. An interesting point in this connection is that during the period when the houses remained free of infection, and in houses which escaped infection altogether, the guinea-pigs harboured much fewer fleas than when infection was present in the house. Thus, the average number of fleas caught on sick guinea-pigs was nearly 15 per animal, whereas on healthy guinea-pigs it was rare to find more than three or four fleas. This difference cannot be explained altogether by the fact that fleas especially attack sick animals, because on a few guinea-pigs, which were observed to be sick and which died from causes other than plague, very few fleas were obtained when the house was free from plague infection. The reason for the larger number on the animals in the infective houses is simply that the fleas readily attack the guinea-pig after the death of their proper host.

(b) On one occasion fleas with bacilli in their stomachs, morphologically resembling *B. pestis*, were obtained in a house in which plague rats were found and in which experimental animals died of plague.

(c) On one occasion fleas removed from a plague rat found in a house in which two guinea-pigs died of plague gave plague to a guinea-pig in the laboratory when placed with it in a flea-proof cage.

(d) In certain experiments monkeys, guinea-pigs and white rats in cages of special construction were introduced into houses in which plague rats were found. The animals which were confined in cages designed so as to protect them from fleas remained healthy, while several control animals in cages similar in construction, but allowing entrance of fleas, died of plague.

(e) On a few of the guinea-pigs small cutaneous phlyctenules were observed in the region where the bubo was situated. These phlyctenules were identical with those which have been seen when infected fleas were fed for experimental purposes on the skin of guinea-pigs.

(f) A point of the greatest importance is the distribution of the buboes in the guinea-pigs. A table (VII) has been constructed to show the regional distribution of the buboes, (1) in the guinea-pigs infected in the Sion houses and (2) in guinea-pigs infected experimentally by fleas in flea-proof cages. The correspondence between the two tables is extremely striking. While this is so the buboes in the Koliwada guinea-pigs do not correspond in point of distribution with those produced by any other known method of infection. It may be added that mesenteric buboes were never found in any of the animals.

TABLE VII.

Comparison of the distribution of the primary bubo in guinea-pigs (a) infected in the houses in Sion and (b) infected experimentally by fleas.

	Sion guinea-pigs	Infected experimentally by fleas
No bubo	2·3 %	0·9 %
Single buboes	93	82·4
Neck	92·5	88·8
Groin	7·5	11·2
Axilla	0	0
Multiple buboes	4·6	16·7
Neck glands involved	100	100
Of total cases with buboes } the neck glands affected }	92·8	90·6

Note.—The only serious discrepancy in the above table is the relatively large proportion of guinea-pigs with multiple buboes amongst those infected experimentally by fleas. This may doubtless be explained by the fact of great concentration of infection in the case of the guinea-pigs in this series.

The above evidence appears to us so convincing that we feel justified in attributing the mode of infection of the guinea-pigs in the infected houses to the agency of infected rat fleas.

At this point reference may be made to the mode of infection of the rats which died of plague during the epizootic in Koliwada and Agriwada. Although the number obtained is small yet it is sufficient to show that the distribution of the buboes corresponds to what has been proved to exist in several thousand plague rats obtained during the epizootic in Bombay City and also to the distribution in rats experimentally infected by fleas in flea-proof cages. We conclude, therefore, that the rat flea was again the transmitting agent of infection in the Sion epizootic.

Noteworthy points arising out of the investigation. Several points of interest which emerge from our study of plague in Sion may be recalled:

(1) It seems worth while drawing attention to certain difficulties which were met with in making these epidemiological investigations. In the first place, we experienced great difficulty in tracing the origin of the epizootic. In similar circumstances it will probably be always impossible to obtain any definite evidence of the medium by which infection is imported. In the second place, an illustration has been furnished of the difficulty of deciding between two alternatives when investigating the source of infection of a human case. Thus the patient in **27. 36 (T)** Agriwada may have been infected at work or he may have received his infection from plague rats in the house.

(2) Although there was a relatively widespread infection of the buildings in Koliwada—45% of the total buildings in the village were proved to be infected—yet there is not the slightest evidence for the view that infection by direct contact with a sick animal played any part in the spread of the infection. This possibility was, indeed, excluded by the nature of the experiment.

(3) Considering the severity of the epidemic the number of plague rats found seems very small, notwithstanding that during the latter part of the observations a very thorough and extensive search was made, short of breaking up the houses, *i.e.* digging up floors, removing tiles, etc. Our experience in this respect points to the danger of concluding that plague rats are absent from an infected locality, unless a thorough search is carried out.

(4) The facts relating to the persistence of infection amongst the rats may be summarised thus:

(a) The infection persisted amongst the rats in the village for two months.

(b) The rate of spread of the epizootic is indicated in the statement that the infection in the rats took six weeks to travel 300 feet.

(c) In the case of two houses, in which it is improbable that reinfection took place, the infection lingered amongst the house rats in one case for at least 10 days, and in the other for 13 days.

Final conclusions. The principal conclusions at which we have arrived after a careful consideration of all the facts of the Sion observations may now be stated. They appear to us to have an important bearing upon the epidemiology of human plague.

(i) The accidental introduction of plague infection, on a single occasion only, into a hitherto uninfected locality led to a widespread epizootic amongst the rats living in the houses.

(ii) Corresponding both in time and in place to the epizootic there was a dissemination of an infecting agent within the houses.

(iii) The infecting agent within the houses which was the cause of the guinea-pig epidemic took the form of infected rat fleas.

(iv) The Koliwada experiment furnishes no evidence that the infection, although widespread, was conveyed in any single instance from one experimental animal to another by direct contagion; on the contrary, the conditions under which the experiment was carried out entirely precluded the possibility of direct infection from animal to animal.

(v) The severity of the epidemic amongst the guinea-pigs was due solely to the accessibility of the animals to rat fleas from infected rats. It cannot with any show of reason be directly associated with insanitary conditions which may have obtained either within or outside the buildings.

III. OBSERVATIONS IN WADHALA VILLAGE. (Map VIII.)

Wadhala is a village with about 1500 inhabitants and is situated $1\frac{1}{2}$ miles to the south of Sion.

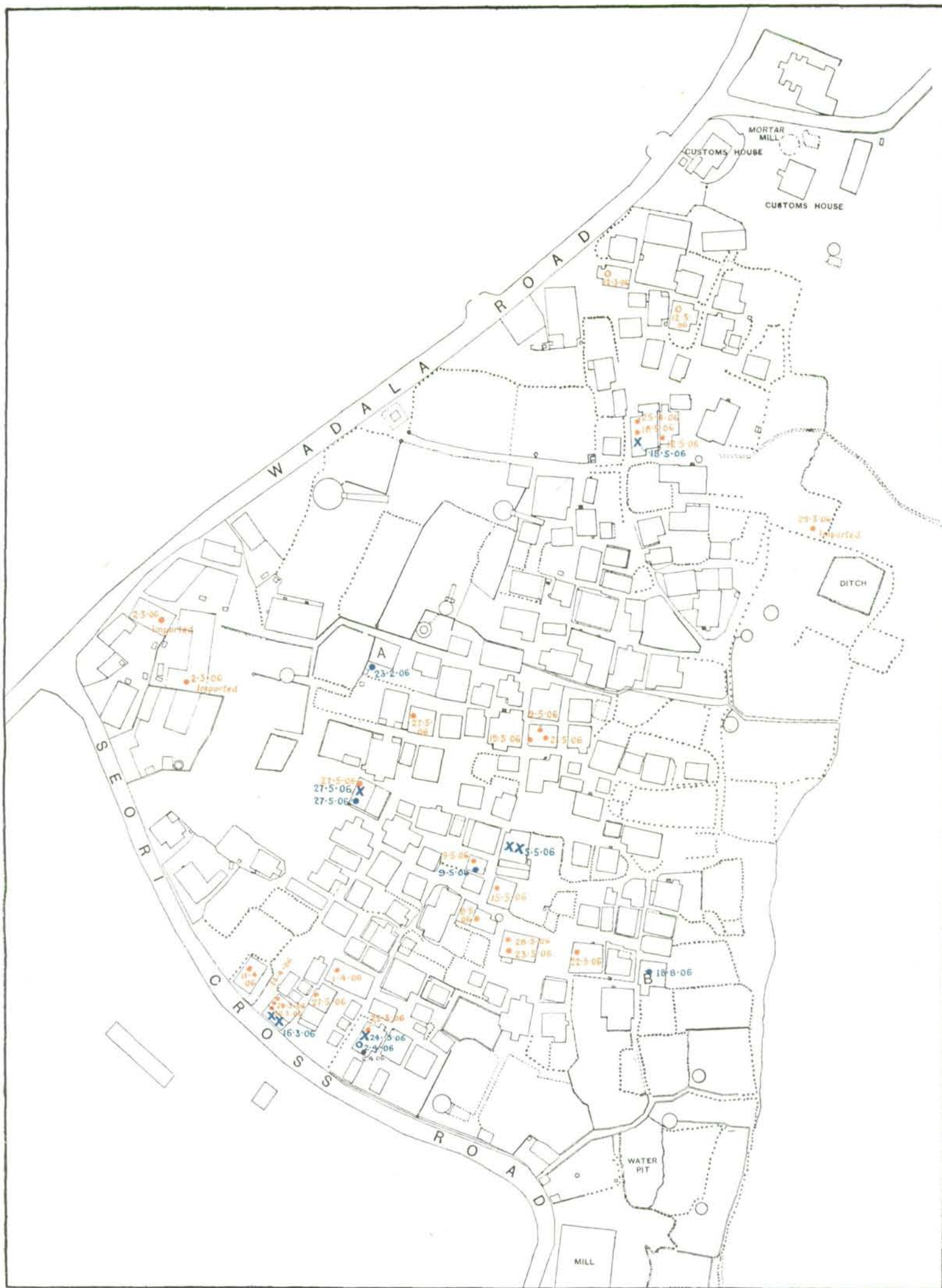
The observations made in this village are very unsatisfactory, chiefly because the villagers shortly after the first indigenous cases of plague occurred evacuated the greater part of the village and went to live in a camp about a mile distant. For this reason the keys of the houses could not readily be obtained, so that it was difficult to gain frequent entrance into them to search for dead rats. As a result the number of rats from the village, which were proved to be plague infected, is very small although there is evidence that an epizootic existed.

The following notes may, however, be recorded, since they serve to illustrate certain points of interest.

The first two cases of plague in the village were found in adjoining buildings on the western side on 3rd March. In both instances there was a definite history of residence in quarters of Bombay City which we knew to be plague infected. One of the patients (1) was brought to Wadhala during his illness, while the other (2) was attacked with the disease on the day after arrival. We could obtain no evidence of rat mortality in either of the buildings. Two guinea-pigs were, however, put into each of the houses on 11th March; no fleas were caught

MAP VIII

WADALA



WADALA

Scale 100 feet to five-eighths of an inch

- Guinea-pig dead of plague
- Human case with date of attack
- Human case (suspicious) with date of attack
- X History of dead rats
- Rats proved to be plague infected
- Putrid rat

on any of the guinea-pigs before removal, and all of them remained healthy. We could discover no evidence of extension of infection from the human cases either amongst rats or men. These cases, therefore, appear to us to be noteworthy as showing that persons coming from an infected district to an uninfected locality, although themselves incubating the disease or suffering from it, do not necessarily introduce the infection into the new locality.

The first case of plague in the village which we had reason to think was indigenous was that of a boy (3) on the south side who was attacked on 25th March. This case offers an example of the difficulty of arriving at a conclusion as to the source of infection even when a careful investigation has been made. The boy was attacked with plague on 25th March and died in two days. We were informed that a dead rat was found in the house on the day before he was attacked; a putrid rat was actually found in the house on 11th April. On 2nd April two guinea-pigs were put into the house. One of these was found dead of plague on 6th April; the other, on which no fleas were caught, was removed at the same time but remained healthy. There can be no doubt, then, that infection was present in the house. On inquiry, however, we found that the boy attended a school just outside the boundary of the village. In this school a dead rat was said to have been picked up on 13th March and another on 15th March. In consequence the school was closed for a week. The school re-opened on 19th March and as already mentioned the boy was attacked on 25th March. Guinea-pigs placed in the school rooms did not contract the disease. It is thus possible, either, that the boy received his infection in the school, or, that he carried infection from the school to the house, the house-rats becoming infected and afterwards transmitting the infection to himself, but dead rats were found close by on 16th March and before on 23rd February elsewhere. On 28th March, a man, Govind Rama (4), living in a house close by, was attacked with plague. This man lived and worked in an infected quarter of Bombay, but occasionally visited this house which belonged to his father. We were informed later that two dead rats had been found in this house about 16th March and that they had been thrown away by this man. A neighbour informed us further that a dead rat was found in the house early in February. In this building also a man (5) was attacked with plague on 30th March, and a sister-in-law (6) of Govind Rama who lived with him was attacked on 14th April and died in two days. She had been living in the camp for 12 days before her illness.

Two other plague cases occurred in buildings not far removed from the house of Case 3. The first (7) is that of a young man attacked on 1st April who died in three days. The other is the case of a man (8) who was attacked on 11th April.

From the map it will be seen that the cases we have just noted occurred within a limited area. A review of the data relating to the presence of dead rats in the houses makes it very probable that the outbreak was associated with an epizootic amongst the house-rats in this area.

As already mentioned the villagers soon after the first cases of plague were found evacuated the greater part of the village and occupied a camp about a mile distant. After remaining in the camp for about two months the villagers returned. Several plague cases occurred shortly afterwards towards the centre of the village. In one or two instances there was a history of finding dead rats in the houses, but only one was obtained by us which was proved to be plague infected. This rat was found on 27th May and an occupant (9) of the house was attacked with plague on the same day. It appeared to us, therefore, that an epizootic existed in this part of the village and that the plague cases were the result of the premature return of the villagers to their houses.

In conclusion we may refer to two interesting cases of rat plague which were unaccompanied by human cases.

(1) A dead rat was found outside a house (A) on 23rd February. It had a submaxillary bubo and other typical signs of plague. It was, therefore, the first event which pointed to indigenous plague infection in the village. And yet we could obtain no evidence of an extension of infection either amongst the rats in this house and the neighbouring houses or amongst the villagers living in the vicinity. The question of the source of infection of this rat is a difficult one. It is a suggestive fact that three coolies working for the Commission lived in this house. All of these men assisted in various ways in the work connected with the daily examination at the laboratory of rats from Bombay City. It is possible, then, that they carried infected rat fleas on their persons and that by this means infection was conveyed to the rat. Again, it may be mentioned that two of the coolies assisted in the investigations we were carrying out in Sion Koliwada, which at this time was badly plague infected.

(2) A rat, caught alive on 18th August on the eastern side (B), was found to be infected with acute plague. Two guinea-pigs were put

into the house but no fleas were taken on them and they remained healthy. We could obtain no evidence as to the source of infection of this rat. No sign of infection, either amongst rats or man, was discovered in the village during $2\frac{1}{2}$ months previous to this date.

IV. OBSERVATIONS IN PAREL VILLAGE. (Map IX.)

In the introduction to the epidemiological studies made in four Bombay villages it was pointed out that these villages had been selected because they occupied isolated positions and because the inhabitants, of three of them at least, followed an employment which kept them confined for the most part to their villages and to the tract of country immediately surrounding them. Parel, the observations in which we are about to describe, differs from the other three villages inasmuch as, although fairly isolated, it has very intimate connection with various parts of the city through a large number of the inhabitants who work there during the day and sleep in the village at night.

Moreover, Parel, in addition to the difference in the nature of the employment of its inhabitants, differs from the other three villages in the following respects:—

(1) The construction of the houses much more closely approaches that found in the city than is the case in the other villages.

(2) The village is furnished with a drainage system, *i.e.* sewers have been constructed along the main streets. Only a few of the buildings, however, are directly connected with this sewage system. None of the other villages possess any sewage system.

1. *General description of the village; its situation, the structure and population of the buildings.*

Parel village is situated almost in the centre of Bombay Island. It forms one of the suburbs of the city and is distant from the Fort about five miles. The village itself is isolated from the rest of the city. It is surrounded on all sides by considerable stretches of more or less open country, or rather the large compounds of residential and other buildings. For example, along the west and north sides it is separated from the extensive compound of the Old Government House by a high stone wall. The southern portion is bounded by a road (Parel Back Road), which separates it from the compound of the Veterinary college and hospital (the Bai Sakarbai Dinshaw Petit Hospital for Animals). Along the

eastern border runs the Parel Tank Road, which separates the village from Parel Hill, a sparsely populated residential quarter of Bombay.

Some details regarding the number of buildings, houses and inhabitants found in each block and in the whole village are given in Table VIII; it will be seen that the population of the village is 3525; that it contains 150 buildings, which are divided into 862 tenements or houses; and that the average number of houses in each building is nearly six. The number of houses in each building, however, varies considerably. The average number of inhabitants per building is 23·5, and the average number of inhabitants in each house is four. Blocks II and III show the largest number of inhabitants per house, but it is to be noted that these blocks contain the majority of the houses with more than one room and are occupied by the better class inhabitants of the village.

TABLE VIII.

Showing number of Buildings, Houses and Inhabitants in Parel Village.

Block no.	No. of buildings	No. of houses	No. of inhabitants	Average no. of houses per building	Average no. of inhabitants per building	Average no. of inhabitants per house
I	31	140	614	4·5	19·8	4·4
II	10	29	140	2·9	14·0	4·8
III	15	68	339	4·5	22·6	5·0
IV	15	103	457	6·9	30·5	4·4
V	14	157	556	12·6	39·6	3·8
VI	20	137	546	6·8	27·3	4·0
VII	45	228	873	5	19·4	3·8
Total	150	862	3525	5·7	23·5	4·1

The construction of the buildings in the village very closely resembles that found in the city. They are, for the most part, flimsily constructed, some being merely huts consisting of a wooden framework covered with palmyra palm leaves, or of bamboo laths besmeared with earth and cowdung. Others are made with brick and mortar or stones bound together with clay. Very few are built with stone and lime. The majority of the buildings are roofed with "country" tiles, but a few are covered with "Mangalore" tiles. The floors of the houses, for the most part, are made of earth, rammed down and covered with cowdung, but in some buildings cement floors are found. Nine characteristic Bombay "chawls" are scattered throughout the village. These chawls are large buildings, of one or more stories, divided up into single room tenements or houses. A number (about 22) of ruined buildings are scattered throughout the village.

In addition to the dwelling houses many native shops are to be found. These are chiefly occupied by petty grocers and grain dealers and are situated along the main village street, marked "Parel Village Road" in the map. There are also four shops which sell firewood and one or two licensed liquor shops. These shops have been mentioned because of their marked infestation with rats. A few goldsmiths and tailors ply their trade in the village. There is a small market where fish, meat, and vegetables are sold in the mornings.

A stable for buffaloes is also situated in the village. These animals supply milk to some of the villagers. The majority of the poorer classes, however, namely those living in one-roomed houses, derive their milk supply from goats, which, with hens, cats and dogs, at night share their common apartment and during the day move about the verandahs and land adjoining the houses. Here the animals find their food supply, which, in part at least, consists of the leavings of the people's meals, carelessly thrown out from their dwellings. This method of disposal of refuse is the common one adopted in the village. The scavenging is in the largest part effected by the above mentioned domestic animals, aided by numerous kites, crows and rats.

These remarks on the structure of the buildings and the habits of the people prepare us to expect a considerable rat infestation, which subject we now pass on to consider.

2. *Observations on the rat infestation of the village.*

A very thorough and systematic examination of the rat infestation was made during the period the village was kept under observation. This was effected by daily setting a number of traps in the different houses in rotation according to the census numbering. In certain houses, however, the tenants refused to take rat-traps because of their religious scruples, while others, after the traps had been set in their houses on a few occasions only, objected to be further troubled with them. The indifference of the majority of the inhabitants to the presence of rats in their dwellings was very noticeable. A few traps were set in places outside dwelling houses, but in these traps *Mus rattus* was seldom taken.

Table IX gives the details of the rats caught alive and found dead in weekly periods from the 20th November 1905 to 1st November 1906, when the rat catching operations were brought to a close. The Table shows that 2195 *Mus rattus* were captured during the year. This number

Plague in Parel Village

TABLE IX.

Showing, for weekly periods, number of rats trapped alive and found dead in Parel Village.

Week ending	Alive					Dead					Plague infected
	rattus	decumanus	Nesokia	Mice	Musk rats	rattus	decumanus	Nesokia	Mice	Musk rats	
20th to 26th Nov. '05	164	0	0	5	36	0	0	0	0	0	Nil
27th Nov. to 3rd Dec. '05	116	0	0	6	13	0	0	0	0	0	"
4th to 10th Dec. '05	125	0	0	6	25	0	0	0	0	0	"
11th to 17th "	178	1	0	2	15	0	0	0	0	0	"
18th to 24th "	115	1	0	11	22	0	0	0	0	0	"
25th to 31st "	128	0	0	5	21	0	0	0	0	0	"
1st to 7th Jan. '06	87	0	0	14	10	0	0	0	0	0	"
8th to 14th "	73	0	0	3	2	0	0	0	0	0	"
15th to 21st "	60	0	0	2	4	4	0	0	0	0	"
22nd to 28th "	70	0	0	13	7	2	0	0	0	0	"
29th Jan. to 4th Feb. '06	42	0	0	1	0	0	0	0	0	0	"
5th to 11th Feb. '06	37	1	0	5	4	0	0	0	0	0	"
12th to 18th "	30	0	0	7	3	0	0	0	0	0	"
19th to 25th "	27	0	0	1	0	1	0	0	0	0	"
26th Feb. to 4th March '06	48	0	0	2	0	0	0	0	0	0	"
5th to 11th March '06	21	0	0	1	0	0	0	0	0	0	"
12th to 18th "	29	0	0	4	1	1	0	0	0	0	1 rattus
19th to 25th "	50	0	0	0	3	0	0	0	0	0	Nil
26th March to 1st April '06	44	0	0	0	5	1	0	0	0	0	1 rattus
2nd to 8th April '06	12	0	0	1	1	2	0	0	0	0	2 "
9th to 15th "	32	0	0	0	1	0	0	0	0	0	Nil
16th to 22nd "	65	0	0	0	3	1	0	0	0	0	"
23rd to 29th "	13	0	0	0	0	1	0	0	0	0	"
30th April to 6th May '06	21	0	0	0	0	0	1	0	0	0	"
7th to 13th May '06	17	0	0	0	2	2	0	0	0	0	1 rattus
14th to 20th "	24	0	0	0	2	0	0	0	0	0	Nil
21st to 27th "	25	0	0	0	1	4	1	0	0	0	1 decumanus
28th May to 3rd June '06	11	0	0	0	0	2	1	0	0	0	1 rattus
4th to 10th June '06	9	0	0	0	0	0	0	0	0	0	Nil
11th to 17th "	13	0	0	0	0	0	0	0	0	0	"
18th to 24th "	16	0	0	0	0	0	0	0	0	0	"
25th June to 1st July '06	25	0	0	0	1	1	1	0	0	0	"
2nd to 8th July '06	26	0	0	2	0	1	0	0	0	0	"
9th to 15th "	9	0	0	0	0	2	1	0	0	0	"
16th to 22nd "	26	0	0	0	2	0	0	0	0	0	"
23rd to 29th "	12	0	0	1	0	0	0	1	0	0	"
29th July to 5th Aug. '06	5	0	0	0	0	0	0	0	0	0	"
6th to 12th Aug. '06	16	0	0	0	0	1	0	0	0	0	"
13th to 19th "	31	0	0	0	1	0	0	0	0	0	"
20th to 26th "	22	0	0	0	1	0	0	0	0	0	"
27th Aug. to 2nd Sept. '06	15	0	0	0	0	0	0	0	0	0	"
3rd to 9th Sept. '06	31	0	0	0	0	0	0	0	0	0	"
10th to 16th "	37	0	0	1	1	0	0	0	0	0	"
17th to 23rd "	42	0	0	0	3	0	0	0	0	0	"
24th to 30th "	29	0	0	0	0	0	0	0	0	0	"
1st to 7th Oct. '06	50	0	0	0	0	1	0	0	0	0	"
8th to 14th "	44	0	0	1	1	0	0	0	0	0	"
15th to 21st "	10	0	0	1	0	0	0	0	0	0	"
22nd to 28th "	38	0	3	5	1	1	0	0	0	0	"
29th Oct. to 1st Nov. '06	25	0	0	3	1	1	0	0	0	0	"
Total	2195	3	3	103	193	29	5	1	0	0	6 rattus 1 decumanus

gives an average of nearly 15 rats per building in the whole village, or 2½ per house. If, however, only the buildings in which a reasonable number of traps had been set are counted, the average number of rats works out at 22 per building.

Table X shows the number of rats caught each fortnight, together with the number of traps set. From these data the number of rats caught each fortnight per 100 traps set has been calculated and is recorded in column 3. The approximate number of times the village had been trapped is stated in column 4 of the Table. A study of this Table shows that, while during the first round of trapping 65 rats were taken per 100 traps set, by the third round this number had been reduced to 49, by the fifth round to 38, by the seventh round to 25, and so on, until on the thirteenth round only 10 rats were taken per 100 traps

TABLE X.

Table showing, for fortnightly periods, the progress of rat catching operations in Parel Village.

Date	No. of <i>rattus</i> trapped alive	No. of traps set	No. of <i>rattus</i> per 100 traps set	No. of times the village was trapped
20th Nov. to 3rd Dec. '05	280	432	64·8	1½
4th to 17th Dec. '05	303	624	48·6	3
18th to 31st „	243	647	37·6	5
1st to 14th Jan. '06	160	640	25·0	7½
15th to 28th „	130	669	19·4	10
29th Jan. to 11th Feb. '06	79	510	15·5	11½
12th to 25th Feb. '06	57	573	9·9	13
26th Feb. to 11th March '06	69	484	14·3	14½
12th to 25th March '06	79	607	13·0	15½
26th March to 8th April '06	56	441	12·7	17
9th to 22nd April '06	97	400	24·2	18
23rd April to 6th May '06	34	347	9·8	19
7th to 20th May '06	41	377	10·9	20½
21st May to 3rd June '06	36	291	12·4	21½
4th to 17th June '06	22	251	8·8	22
18th June to 1st July '06	41	252	16·3	22½
2nd to 15th July '06	35	216	16·2	23
16th to 29th „	38	252	15·1	23½
30th July to 12th August '06	21	149	14·1	24
13th to 26th August '06	53	143	37·0	24½
27th August to 9th Sept. '06	46	158	29·1	25
10th to 23rd Sept. '06	79	230	34·3	25½
24th Sept. to 7th Oct. '06	79	250	31·6	26
8th to 21st Oct. '06	54	162	33·3	26½
22nd Oct. to 1st Nov. '06	63	186	33·9	27
Total	2195			

set. This latter number is calculated on the number of rats caught during the fortnightly period 12th to 25th February.

After this date the number of rats taken remained at a comparatively low figure till the middle of August, when during the 24th round of trapping it rose to 37 per trap set, and thereafter was maintained at about this figure, till the rat catching operations were suspended. During the twenty-seventh and last round of trapping 34 rats per 100 traps set were taken, a number which is more than half the number taken at the first round. It is to be remembered that by this time over 2000 rats had been removed from the village.

We can conclude, then, that the rat infestation of Parel is very considerable and that, despite the capture and removal from the village during the year's operations of a large number of rats, equivalent to nearly two-thirds of the human population, the number at the end of the operations was apparently not very greatly diminished. The rats removed were evidently rapidly replaced by young ones, the effect of this being most marked during the month of August, when in Bombay the fecundity of *Mus rattus* is greatest (see above, p. 749).

TABLE XI.

Showing rat infestation and its relation to population in each block in Parel Village. Only for buildings in which at least 27 traps had been set.

Block No.	Rats caught	Traps set	Rats caught per 100 traps set	Population of trapped buildings	No. of buildings trapped	Average population of trapped buildings
I	457	1466	31	495	18	28
II	85	343	25	107	8	13
III	398	954	42	267	10	26
IV	184	1257	15	396	11	36
V	305	1339	23	600	13	46
VI	468	1663	28	533	19	28
VII	180	1511	13	667	17	39
Total	2077	8533	24	3065	96	32

We can now study the rat infestation of the village in greater detail and for this purpose we would refer the reader to Tables XI and XII. In these Tables only the buildings in which at least one or more traps were set during each round of trapping the village are included. In Table XI the figures for each block, in XII for each building, are recorded. From Table XI it will be seen that blocks IV, V and VI, although they contained a large population or a large average number of inhabitants per building, yet yielded, when compared with the other less populous

blocks, a smaller number of rats. When we consider individual buildings, as displayed in Table XII, we find that the population of a building has no direct relation to the number of rats it is possible to capture in it. We also observe that rat infestation of buildings is very irregular, some containing many rats, others none or a few only.

TABLE XII.

Block I.

Building No.	No. of rats	No. of traps	Rats per 100 traps	Population
3	16	42	38	47
4	51	148	35	67
5	21	106	24	38
7	28	50	56	7
8	49	113	38	24
10	14	55	25	28
11	88	110	80	7
12	103	196	53	67
13	11	57	19	18
15	5	87	7	16
16	6	97	6	27
17	0	96	0	27
19	17	47	36	21
21	16	98	16	21
23	1	27	4	27
25	19	35	54	7
26	1	41	2	35
29	11	61	18	12
Total	457	1466	31	496

Average rats per 100 traps :—31.

Average inhabitants per building :—28.

Block II.

1	19	66	29	13
2	2	22	9	5
3	25	79	32	19
5	11	29	38	2
6	10	55	18	10
7	7	22	32	15
8	7	42	16	12
9	4	28	14	31
Total	85	343	25	107

Average rats per 100 traps :—25.

Average inhabitants per building :—13.

*Plague in Parel Village**Block III.*

Building No.	No. of rats	No. of traps	Rats per 100 traps	Population
1	0	84	0	13
4	14	47	30	26
7	301	393	76	70
9	10	50	20	20
10	13	25	52	18
11	19	149	13	34
12	8	40	20	11
13	13	51	25	11
14	11	61	18	28
15	9	54	16	36
Total	398	954	42	267

Average rats per 100 traps :—42.
Average inhabitants per building :—26.

Block IV.

1	22	138	16	37
2	8	162	5	34
3	19	169	11	19
4	17	137	12	54
5	24	127	19	70
6	21	105	20	69
7	35	102	34	23
8	18	126	14	36
9	7	83	8	7
10	10	85	12	11
11	3	23	13	36
Total	184	1257	15	396

Average rats per 100 traps :—15.
Average inhabitants per building :—36.

Block V.

1	20	220	9	56
2	8	165	5	45
3	10	47	21	26
4	10	46	21	26
6	9	33	27	2
7	2	31	6	1
8	34	88	39	40
9	28	33	84	8
10	161	382	42	138
11	6	111	5	119
12	11	88	13	31
13	3	50	6	59
14	3	45	6	49
Total	305	1339	23	600

Average rats per 100 traps :—23.
Average inhabitants per building :—46.

Block VI.

Building No.	No. of rats	No. of traps	Rats per 100 traps	Population
1	4	113	4	53
2	30	145	21	27
3	70	60	117	12
4	20	46	43	3
5	13	105	12	5
6	32	128	25	25
7	36	74	48	16
8	9	28	32	11
9	9	83	11	19
10	13	41	32	14
11	38	102	37	35
12	2	89	2	37
14	5	55	9	35
15	21	39	60	3
16	21	109	19	26
17	11	108	10	30
18	12	78	15	41
19	56	109	41	40
20	66	155	43	101
Total	468	1667	28	533

Average rats per 100 traps :—28.

Average inhabitants per building :—28.

Block VII.

1	3	82	4	15
6	29	98	30	31
7	4	133	3	21
8	4	107	4	35
9	27	256	11	101
10	18	202	9	108
11	48	62	77	55
12	5	56	9	26
16	4	45	9	8
17	7	27	26	5
31	1	32	3	33
32	3	54	6	53
33	7	113	6	47
36	15	111	13	83
42	3	40	8	20
43	2	51	4	16
44	0	42	0	10
Total	180	1511	13	667

Average rats per 100 traps :—13.

Average inhabitants per building :—39.

We would now draw attention to a few of the worst rat infested buildings and consider what features they had in common, which might offer an attraction to rats. Details regarding five buildings of this description are given in Table XIII.

TABLE XIII.

Details of badly rat infested buildings in Parel Village.

Serial No.	Block No.	Building No.	Rats caught	Traps set	Rats per 100 traps	No. of tenements in building	Population of building
1	VI	3	70	60	117	5	12
2	V	9	28	33	84	3	8
3	I	11	88	110	80	2	7
4	VII	11	48	62	77	17	55
5	III	7	301	393	70	16	70

The first building on the list is an old one, with ground-floor and upper story. The walls are made of bricks covered with plaster and the roof of country tiles. The building is divided into five tenements and contains twelve inhabitants. Bags, containing grain and ground nuts, had been stored on the ground-floor verandah for some months. Further, there is a loft in which an accumulation of rubbish had been collected. Seventy rats were caught in sixty traps set in this building, giving a take of 117 rats per 100 traps set. The second building is a small ground-floor one with a roof of country tiles. The floor is of rammed mud and the walls of stone jointed with clay. They are both riddled with rat holes. It is divided into three tenements and inhabited by eight people. One room, the largest, in the centre of the building is used as a grain merchant's shop, where grain of all kinds is stored in bags. In this building 28 rats were caught in 33 traps set. The third building very closely resembles the second in structure. It is divided into two tenements, both of which are used for petty grocer's and grain merchant's shops, as well as for the living rooms of the seven inhabitants. The floor and walls are riddled with rat holes. Eighty rats were captured in 110 traps set. The fourth building very closely resembles the first in structure, being an old building, which has evidently seen better days. It consists of a ground-floor and upper story. It has now been divided up into seventeen tenements occupied by 55 inhabitants. In this house 48 rats were caught in 62 traps. The fifth building is in some ways the most noteworthy, inasmuch as it yielded the largest number of rats, namely, 301 caught in 393 traps. It also is an old building, consisting of ground-floor and two upper stories, the topmost deserving the name of a loft rather than a story.

In structure it resembles the other buildings mentioned above. On the ground-floor in front there are two small grocer's shops. The floor of these shops is made of mud and is riddled with rat holes. The top story or loft is divided into a number of rooms by wooden partitions. The population of this building, numbering 70, is distributed among 16 tenements.

These five rat infested buildings are all very old, the walls and floors being riddled with rat holes. The majority possess ample attraction for rats in the grain shops on the ground-floors. Further, rats are afforded shelter in the country tiles of the roofs, as well as in the soft floors and crumbling walls. It is noteworthy that these buildings include all the grocers' shops in the village in which we were allowed to set traps. The remaining shops of this type, in which we were not allowed to set traps because of the religious scruples of the owners, when examined, gave ample indication of being rat infested. It would appear, then, that the presence of such shops in a building markedly increases the rat infestation.

TABLE XIV.

Details of rat free (?) buildings in Parel Village.

Serial No.	Block No.	Building No.	Rats caught	Traps set	No. of tenements	Population
1	I	17	0	96	6	27
2	III	1	0	84	3	13
3	VII	44	0	42	3	10

In the whole village only three buildings, which had been properly trapped, showed a complete absence of rats. The details of these buildings are given in Table XIV. One of them, namely, the second on the list, can for the following reasons hardly be said to be rat free. The building has a ground-floor and upper story. The ground-floor is used as a godown, in which a large quantity of rice is stored. The upper story is divided into three single room tenements. It was in these rooms that traps were set, none being placed in the rice godown below. An examination of the godown showed rat holes and other evidence of the presence of rats. It is possible that rats were attracted by the abundant food supply to the godown rather than to the rooms above in which the traps were set. Of the other two rat free buildings we can give no very satisfactory explanation, other than that they were occupied by very poor people, who brought their food supply in daily and probably left little or nothing, after partaking of their meals, which could support rats.

We may now briefly refer to certain other points connected with the rats in the village. (1) Twenty-nine *Mus rattus* were picked up dead in the village, six of these dead rats being proved to be infected with plague. The remaining number, twenty-three, was all that we were able to collect, which might be said to represent the normal apparent mortality among this species of rat. This number must evidently fall far short of the real normal mortality. In order to further investigate this point we opened up some rat holes and burrows and exposed skeletons of rats in them. It would appear, therefore, that many rats must die in places which are not readily accessible to man. (2) It is interesting to note the presence of *Mus decumanus* in this village, probably associated with the sewage system. Three rats of this species were trapped alive and five were found dead, one of these latter being proved to be plague infected. (3) Three *Nesokia bengalensis* were trapped alive and one was found dead. (4) Mention need only be made of a number of mice, 103, which were trapped alive. This number, however, gives no adequate idea of the proportion of mice to rats in the village, as the traps used were adapted for rats and not for mice, the latter being easily able to escape. One of the houses which was free from rats, viz. the first on the list in Table XIV, was infested with mice.

3. *Remarks on plague among the rats in the village.*

We now pass on to consider the presence of plague among the rats in the village. Although 1321 rats caught alive were examined, up till the week ending 11th March not one among that number was found infected with plague, either in the acute or chronic form. The whole village by this time had been trapped fourteen times. We were, therefore, fairly assured of the absence of plague among the rats at this date.

However, the possible infection of the rats of the village from a northerly direction was brought home to us by the discovery of plague-infected rats in some godowns in the compound of Old Government House on the 10th and 11th of January 1906 (*vide* Map IX). We have already pointed out that this compound is separated from the village by a high stone wall and it is interesting to note, that although the village is very adjacent to these godowns the infected rats seem to have been kept out of the village for some months by this wall. Part of this infected rat colony appears to have migrated in a westerly direction, along the wall surrounding the village, for a plague-infected animal was

MAP IX

PAREL VILLAGE

Showing plague cases and plague
infected rats



PAREL VILLAGE

Showing plague cases and plague infected rats

Scale 100 feet to five-eighths of an inch

- Human plague attack (serial number)
- Plague infected *M. rattus*
- Plague infected *M. decumanus*

found in this direction, still within Government House compound, more than a month later, namely, on the 17th February. A strict watch was kept for the appearance of plague among the rats of the village along this northern boundary, but no evidence of an epizootic was obtained till the 17th of March, when a dead plague-infected rat was found to the east in Block V, building 1. Adjacent to this building an opening, in the form of an open doorway, exists in the wall separating Government House compound from the village: this is indicated by a cross in the Map. It seems highly probable that the epizootic in the village was started by an extension through this opening of the epizootic in Government House compound. A second plague-infected *rattus* was found in the same building on the 29th March. This was followed by the discovery of a plague-infected rat on 3rd April in the compound of building No. 11, Block IV, adjacent to a latrine, marked L in Map IX. This latrine was used by the inhabitants of building 11. A fourth plague-infected *rattus* was found on the 5th April, lying on the ground at the corner of building 1, Block V. Whether the rat had died here or been thrown out of the house we could not ascertain. As will be seen from the map all these rats were found in the same neighbourhood.

No more plague-infected rats were found in this neighbourhood after the 5th April and the epizootic here had apparently come to an end. Why this should have been the case we can only speculate, but it is noteworthy that in the week embraced between the 1st and 7th April there was a marked fall in the number of plague-infected *rattus* obtained throughout Bombay. It is also worthy of note that the rat infestation of the houses immediately adjoining building 1, Block V, namely, buildings 2, 3, and 4 of this block and 10 and 11 of Block IV, was slightly below the average for the houses in these blocks (*vide* Table XII).

It remains now to refer to three plague-infected rats found in the village in the month of May. The date and position where these rats were found are shown in the Map. The first rat was found on the 9th and the second on the 24th May. This latter rat belonged to the species *Mus decumanus*, while the former was a *Mus rattus*. The third rat, also a *Mus rattus*, was found on the 28th May. In connection with these rats it is worth noting that during this month the number of imported human cases of plague was very large. The epidemic, as far as the village was concerned, was apparently at its height, while the epizootic had rapidly declined. It is possible that these rats acquired the disease from infected rat fleas imported by man. That the epizootic did not extend from these rats might be due to the fact that the conditions

Plague in Parel Village

TABLE XV.

Showing Plague Cases in Parel Village.

Serial no.	Names	Block	Building	House	Age	Sex	Occupation	Dates of			
								Attack	Death	Putting in guinea-pigs	Taking out guinea-pigs
1	Ládki Wallabhji	VI	1	16	16	F	Household work	18. 3. 06	22. 3. 06	22. 3. 06	23. 3. 06
2	Laxmíbai Shivá	V	10	84	18	F	„ „	21. 3. 06	25. 3. 06	30. 3. 06	7. 4. 06
3	Súndrábái Náráyán	IV	11	89	11	F	Nil	3. 4. 06	8. 4. 06	9. 4. 06	12. 4. 06
4	Bárki Dinánáth	IV	11	92	30	F	Household work	4. 4. 06	11. 4. 06	9. 4. 06	12. 4. 06
5	Ranchod Niláji	IV	11	92	60	M	Fitter G.I.P. Ry.	3. 4. 06	12. 4. 06	—	—
6	Báloo Shivá	V	12	135	18	M	Cooly	6. 4. 06	7. 4. 06	—	—
7	Bhimá Vishnoo	V	1	12	30	F	Household work	13. 4. 06	Recovered	—	—
8	Báboo Báloo	V	1	1	6	M	Nil	13. 4. 06	15. 4. 06	—	—
9	Gangábái Rámá	I	26	118	18	F	Mill hand	20. 4. 06	24. 4. 06	24. 4. 06	1. 5. 06
10	Mooktábái Yessoo	VI	Market Room	40	40	F	Vegetable Seller	21. 4. 06	24. 4. 06	23. 4. 06	25. 4. 06
11	Govardhan Mátádin	I	10	53	23	M	Cooly G.I.P. Ry.	22. 4. 06	Recovered	23. 4. 06	25. 4. 06
12	Bábáji Krishná	VI	9	41	70	M	Goldsmith	22. 4. 06	24. 4. 06	24. 4. 06	28. 4. 06
13	Jayerám Atmárám	VII	11	129	20	M	Carpenter	25. 4. 06	Recovered	—	—
14	Náráyan Ráoji	VI	20	134	45	M	Mill hand	30. 4. 06	2. 5. 06	2. 5. 06	8. 5. 06
15	Krishná Rámá	III	7	16	26	M	„	3. 5. 06	5. 5. 06	5. 5. 06	15. 5. 06
16	Haribá Ráoji	VII	—	—	20	M	„	5. 5. 06	11. 5. 06	12. 5. 06	17. 5. 06
17	Ratin Bhámbiá	V	1	8	35	F	Sweeper	9. 5. 06	11. 5. 06	12. 5. 06	17. 5. 06
18	Santoo Ránoo	VI	20	134	35	M	Mill hand	9. 5. 06	13. 5. 06	12. 5. 06	17. 5. 06
19	Ganoo Mánkoo	I	5	28	25	M	„	10. 5. 06	15. 5. 06	12. 5. 06	17. 5. 06
20	Párvati Bhágyá	V	11	133	18	F	Household work	10. 5. 06	19. 5. 06	20. 5. 06	31. 5. 06
21	Shivrám B. Parelkar	IV	14	96	20	M	Clerk B.B.L.	12. 5. 06	Recovered	—	—
22	Jánoo Vithoo	V	10	79	25	M	Mill hand	14. 5. 06	22. 5. 06	23. 5. 06	31. 5. 06
23	Gangáram Ratnoo	V	1	4	22	M	Cooly P. W. Dept.	19. 5. 06	21. 5. 06	19. 5. 06	23. 5. 06
24	Bhágoo Vithoo	VII	12	134	30	F	Mill hand	25. 5. 06	Recovered	25. 5. 06	31. 5. 06
25	Báloo Vithoo (son of 24)	VII	12	134	6	M	Nil	25. 5. 06	Recovered	25. 5. 06	31. 5. 06
26	Bháoo Lingoo	I	5	28	30	M	Barber	27. 5. 06	Recovered	29. 5. 06	4. 6. 06
27	Vaná Himat	V	10	64	25	M	Moneylender's clerk	16. 7. 06	20. 7. 06	—	—
28	Samná Doolá	V	10	74	28	M	Grain Merchant	27. 7. 06	31. 7. 06	2. 8. 06	6. 8. 06

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No of fleas found	Adjudged source of infection	Remarks
3+1	Imported	1. A family living in Samuel St. were attacked with plague. In all 4 cases occurred. One of these Ladki was removed from the house in Samuel St. to Parel. She died a few hours after her arrival in Parel. The bedding and some other kit were left in the rooms where she had died. On the day of her death 2 guinea-pigs were put in. They were examined the next day and gave 4 fleas. The pig that gave 3 fleas died of plague on 26. 3. 06.
0+2	?	2. A suspicious case. No bubo. Lived with her husband and brother-in-law. Although formerly employed in a mill, she had not been at work for more than a month, occupying herself in household duties and carrying her husband's meals to the G. I. P. Ry. workshop at Byculla.
2+0	Local	3, 4, 5 Dead rat found in the compound of this house on 3. 4. 06. Proved plague-infected.
—	"	"
—	Imported	6. Visited the Laboratory in search of employment in connection with the examination of rats from the City.
—	Local	7. Plague-infected rats found in or near this "Chawl" on 17th and 29th March and 5th April 06.
—	"	8. " " " " " " " " " " " "
7+10	Imported	9. Several deaths had occurred amongst the mill hands where she had been working. "
1 cat flea	?	10. Visited many parts of the city buying and selling vegetables.
1+0	Imported	11. Plague was very prevalent in the neighbourhood of his place of employment at this time.
1+0	"	12. Frequently visited Lalwadi, an infected portion of the City.
—	"	13. Dead rats found at the place of his work in Abdul Rahman Street.
16+11	"	14, 15, 16, 18, 19, 24 and 25. Dead rats found in the mixing department of the Moon Mills. 2 guinea-pigs were put into this room on 12. 5. 06. One gave 108 fleas and the other 150 fleas. These fleas were put on to a fresh pig in a flea-proof cage. Neither of the pigs put in the mixing room died of plague, but the pig on which the fleas were placed in a flea-proof cage at the Laboratory died of plague on 20. 5. 06. In addition to the cases herein recorded who lived in Parel Village, three other cases were probably associated with the infection in the mixing room.
1+0	"	"
Nil	"	17. Came to Parel Village, ill with plague. She had been nursing her daughter who was suffering from plague.
Nil	"	18. Moon Mills case.
Nil	"	19. " " " " " " " " " " " "
Nil	"	20. Was employed as a daily labourer in a house near the Moon Mills, which was infected at this time.
—	"	21. Employed at the Laboratory, where large numbers of infected rats were being received from the City. This patient had been inoculated
2+0	"	22. Was employed in the blow room of the Indo-China Mills, Sewri. This mill is close to the Moon Mills mentioned above.
1+0	?	23. Was employed in various parts of the City in connection with his work in the P. W. Department.
Nil	Imported	24. She was employed in the godown of the Moon Mills, where she had seen dead rats.
Nil	"	25. Moon Mills case.
Nil	?	26. Source of infection unknown. Always worked in the village. A plague-infected <i>decumanus</i> found not far from his house two days before he was attacked. Lived in the same room as case no. 19. Had an inguinal bubo.
—	?	27. Came from his native country a fortnight before being attacked. He wandered about in Bombay in search of employment and found it in Parel on 13th, three days before he was attacked.
Nil	?	28. Was employed by a grain dealer. Had not left the village for a fortnight before being attacked. Handled grain which was frequently brought to the village from the City. No dead rats found in the house. Had a well-marked axillary bubo.

at this time in Bombay were evidently very unfavourable for its propagation, as will be seen from the rapid decline in the number of plague-infected rats received from the city at the laboratory during this month (*vide supra*).

4. *Plague among the inhabitants, and its relation to rat plague.*

We pass on now to consider plague among the inhabitants of the village. Table XV gives the details of the cases, arranged in serial order according to the date of the attack. They appear on Map IX as red spots.

In arriving at a diagnosis of the disease it was considered expedient not to attempt to take cultures, as any endeavour in this direction, we felt sure, would lead to the concealment of cases and frustrate our object in obtaining as early information as possible of the occurrence of the disease among the villagers. We had, therefore, to rely on purely clinical methods. In only one case, however, had we any doubt as to the cause of death, namely, case 2. This case was not seen by us during life, but was certified as a plague death by the district registrar.

From Table XV it will be seen that 28 cases of plague occurred in the village, giving an attack rate of nearly 8 per 1000 inhabitants. Twenty-one of these cases ended fatally, giving a case mortality rate of 75%. Table XVI gives the number of deaths each month which occurred in the village from plague, cholera and other causes. From this table it will be seen that throughout the year 23% of total deaths in the village were due to plague.

Human plague began in Parel on March 21st with a case (2) on the east side of the village. There was no bubo and the diagnosis was doubtful; no source of infection could be definitely determined. The next day, a case (1) was brought from Bombay and died the same day in the south-west corner of the place. These were followed by a series of five cases (3, 4, 5, 7, 8) in the north-east corner, falling ill between April 4th and April 13th and definitely associated in time and place with the epizootic which was found to prevail in the same group of houses between March 17th and April 5th. The remaining 21 cases were not associated with any ascertained rat plague in Parel. Nine of them (13, 14, 15, 16, 17, 18, 19, 24 and 25) were imported already infected at various dates between 25th April and 25th May: seven (6, 9, 11, 12, 20, 21 and 22) were probably infected outside the village as they had recently visited places where rat plague was known to be present: while the

source of the infection in the remaining five could not be determined. Though one of the imported cases infected the house in which she died, as shown by the capture of plague-infected fleas therein, none of them gave origin to any epizootic.

TABLE XVI.

Showing the number of deaths from Plague and other causes for each month in Parel village.

Months	Plague	Cholera	Other causes	Total
November '05	0	0	3	3
December '05	0	0	3	3
January '06	0	0	5	5
February '06	0	0	3	3
March '06	2	0	6	8
April '06	9	0	1	10
May '06	8	7	6	21
June '06	0	1	5	6
July '06	2	2	8	12
August '06	0	2	6	8
September '06	0	0	6	6
October '06	0	0	5	5
Total	21	12	57	90

We may now proceed to the details of these cases, grouping them in four groups according to the adjudged mode of infection.

Group I. *Cases in which the infection could be attributed to the epizootic in the Village.*

Only five cases (3, 4, 5, 7 and 8) could be definitely attributed to the presence of the epizootic in the village.

The first three cases probably derived their infection from the epizootic, represented by the rat found in the compound of the building in which they lived (Building 11, Block IV). This rat was found on the morning of the 3rd March lying dead near a latrine which was used by the inmates of this building. Although the three patients were related to one another, Nos. 3 and 4 lived in one set of rooms, while No. 2 lived in another adjacent set of rooms. In none of the rooms had dead rats been found.

Cases 7 and 8 occurred in building 1, Block V. Their infection might reasonably be attributed to the presence of plague among the rats in this building, as evidenced by the finding of dead plague-infected rats in or near this building on the 17th and 29th March and 5th April. Both cases were attacked on the 13th April. They occupied

different rooms in the building. Case 8 lived with three other persons in a single room on the 1st story of the building. Case 7 lived with his mother and another child in a room on the ground-floor. In neither of these rooms had dead rats been found.

None of the five cases, so far as we could learn, had been in direct contact with plague-infected rats; nor had dead rats been found in any of the rooms occupied by them.

The day after the death of the patient and six days after her attack two guinea-pigs were placed in the rooms occupied by case 3. On examination after three days only two fleas were taken. The guinea-pigs remained healthy.

Group II. *Cases in which the infection could not be attributed to the village, some of the patients (a) having been employed in a place which was proved to be infective, while others (b) had been in contact with dead rats somewhere outside the village.*

(a) This group includes cases 14, 15, 16, 18, 19, 24, and 25. They were all employed at a cotton spinning mill in the Sewri section of Bombay. Dead rats had been found in several parts of this mill, but especially in the mixing department, where cases Nos. 14, 15, 18 and 19 worked. Two of these men had thrown out the rats. Cases 16 and 24 were employed in other parts of the same mill. Case 24 lived with her son (25) who occasionally visited the mill with his mother. The woman had noticed dead rats in the godown where she worked. All these cases, and three others investigated by us who lived in other parts of Bombay but worked in this mill, were attacked between the 30th April and 10th May.

An interesting experiment was done in the mixing room in the mill. On the 12th May two guinea-pigs were placed in it; they were examined for fleas on the 14th May. On one guinea-pig 108 and on the other 150 rat fleas were captured. After the fleas had been removed the guinea-pigs were taken to the laboratory and isolated. They remained healthy. The fleas were transferred to a fresh guinea-pig confined in a flea proof cage in the laboratory. This guinea-pig died of plague on the 20th May. The mixing room was thus proved to be infective.

It is important to note that these cases lived in different parts of Parel village and that we could obtain no evidence of a rat epizootic at their homes which did not prove infective to guinea-pigs. The infection therefore may reasonably be attributed to the mill in which they worked.

(b) *Cases 1, 13 and 17* are included in this group.

Case 1. This woman was brought to the village when moribund. She lived with her family in a house in Samuel Street in Mandvi district of Bombay City. Dead rats had been found in this house a few days before she, with other three members of her family, was attacked with the disease. Her friends believing that a change of air would do her good, hired a room in Block V building 1 in Parel village and brought her there on the 21st March. She died on the evening of her arrival. Her friends, after removing the body, quitted the house, leaving behind them a certain amount of kit and bedding. Two guinea-pigs were placed in the room on the 22nd March. These animals were examined for fleas on the 23rd, four rat fleas being taken, three on one and one on the other. The guinea-pigs were isolated in the laboratory. The fleas were not dissected. The guinea-pig on which the three fleas were found died of plague. As will be seen from the map we had at this time no evidence of the presence of plague among the rats in this part of the village. Bearing in mind this fact and the experiments recorded in a previous report, which showed that animals did not contract the disease in contact with the sick, if fleas were excluded, it is more than probable that the guinea-pig was infected by rat fleas imported to the village by the patient or her friends.

Case 13. This man was employed as a carpenter in the Chukla section of Bombay City. Three days before he was attacked he had noticed dead rats in his workshop.

Case 17 of this group only remains to be detailed. She had been living in the building, Block V, building 1, in which plague-infected rats had been found a month previous to her attack. She left her house to nurse her daughter in another part of the city. Dead rats had been found in this latter house. She returned to Parel after the death of her daughter, herself at this time suffering from plague, and died there on the 11th May 1906.

It remains to be stated that guinea-pigs were placed in the rooms in Parel occupied by cases 14, 15, 16, 17, 18, 19, 24 and 25. Cases 14 and 18 and cases 24 and 25 lived in the same rooms. Guinea-pigs were put into the room occupied by cases 14 and 18 on two occasions, namely, on the 2nd May immediately after the death of case 14, and two on the 12th May the day before the death of case 18. In all the rooms tested, except in those occupied by cases 15 and 16, no rat fleas were captured on the guinea-pigs, which all remained healthy. In the room occupied by case 16 only one flea was trapped, while in the

room occupied by case 15 twenty-seven fleas were captured. It should be noted that this latter room was situated in one of the most notoriously rat infested buildings in the village, namely, building 7, Block III, in which 301 rats had been captured during the year's operations.

This group of cases which presumably received their infection outside the village constitutes 36 % of the total plague cases which occurred in the village. As will be seen when we consider the next group of cases, there is good reason to believe that some other cases also acquired their infection outside the village.

Group III. Cases which might have acquired their infection by visiting places, in which epizootic plague was known to be present about the time they were attacked.

Seven cases, namely, 6, 9, 11, 12, 20, 21 and 22, fall into this group. Two of these cases, namely, 6 and 21, might have been placed with some reason in group II. These men had visited the laboratory, where an extensive examination of plague-infected rats was being carried on. *Case 6* had come in search of employment in connection with these operations and had stood on one or two occasions near the place where the dead rats were prepared for examination. The patient had not been inoculated. *Case 21* had been employed in the laboratory for some time; he had, like the rest of the staff of the laboratory, been inoculated with Haffkine's vaccine. The room where he worked was adjacent to the verandah where the rats were examined.

Case 9 was employed in a mill in Bombay where several other of the workers had been attacked with plague. The patient herself had not noticed or heard that dead rats had been found in the mill. Several plague-infected rats had, however, been found in the neighbourhood of the mill before this patient was attacked. The same remarks apply to *case 11* who was employed in a railway workshop near the above mentioned mill.

Case 12 occasionally visited the district in which the above mentioned mill and workshop are situated. He had not seen dead rats in any place he visited, nor had he been in any house where he was aware that plague cases had occurred.

Case 20 was employed as a daily household servant in a building close to the mill in Sewri district, where cases 14, 15, 16, 17, 18, 19, 24 and 25 probably derived their infection. She had not personally noticed dead rats at the place of her work.

Case 22 was employed in another mill, adjoining the above mentioned one in Sewri district. He had not noticed or heard of dead rats being found in this mill.

Two guinea-pigs were placed in each of the rooms occupied by the cases of this group, except in the rooms occupied by cases 6 and 21, which cases, as we have seen, probably contracted the disease at the laboratory. The number of fleas caught on the guinea-pigs exposed in these rooms is recorded in Table XV. Not one of the guinea-pigs contracted plague.

From the remarks made above we have fair grounds for concluding that the cases of this group acquired their infection outside the village. If we add these seven cases to the ten cases of group II we can calculate that 17 or 61 % of the total plague cases acquired their infection outside the village.

Group IV. *Cases in which the source of infection was undetermined.*

In this group we have cases 2, 10, 23, 26, 27 and 28. *Case 2* was a suspicious case of plague. She died after suffering from fever without bubo for two days, the disease being certified as plague by the district registrar. She was employed in a mill in the Sewri district of Bombay, but had not been to work for more than a month. She occupied herself in household duties and was in the habit of carrying her husband's midday meal to his place of work at the Great Indian Peninsular Railway Workshop at Byculla. She had not noticed dead rats at any place she had visited. No dead rats were found in her house nor, as far as we were aware, at her husband's workshop. Two guinea-pigs placed in the room in which she lived with her husband and brother-in-law remained healthy, and only two rat fleas were found on the animals.

Case 10: a female, who had lived with her husband in a small hut near the market, where they sold vegetables and groceries. She had been in the habit of visiting various parts of the city for the purpose of buying these commodities. One cat flea was captured on the two guinea-pigs placed in this hut, the animals remaining healthy after being isolated in the laboratory.

Case 23 lived in a building (Block V, building 1), in which plague-infected rats had been found more than a month previous to the date on which he was attacked. He was employed in various parts of the city in connection with the work of the Public Works Department. Two guinea-pigs placed in his house, a single room, on the day he was attacked trapped only one rat flea. The guinea-pigs remained healthy.

Case 27 is a similar case to the above. This man had come to Bombay in search of employment, for which purpose he wandered about and slept in various parts of the city. Three days before he was attacked he had found employment in Parel village.

Case 26 presents some features of interest. He lived in the same house as case 19. He was a barber by occupation and in this capacity visited all parts of the village, but, however, seldom went outside it. He was attacked twelve days after the death of case 19. Two guinea-pigs, which had been placed in the house during the illness of case 19 and removed from the room ten days before the present patient was attacked, remained healthy. Moreover, two fresh guinea-pigs placed in the room two days after this latter patient was attacked also remained healthy. We, therefore, consider that it is probable that this patient acquired his infection outside the house he lived in and quite apart from case 19. It is interesting to note that a dead plague-infected *Mus decumanus* was found on the 24th May, that is three days before this man was attacked, near building 8, Block I, on a vacant piece of ground, not far from the patient's house and in the direct line of a short cut between his house and the main road of the village.

Case 28 is also noteworthy. He had lived for some time in the village and had not recently left it even to go to the city. He was employed in a grain merchant's shop and had to handle the grain which was frequently imported from Bombay. No infected rats had been found for some time in the village and no dead rats had been found in or near his house throughout the year the village was under observation. Parts of the city however, even at the season when the patient was attacked, contained plague-infected rats. The source of his infection can only be conjectured, but it seems possible that he might have been infected in connection with the handling of the grain in the shop where he was employed.

In reviewing the whole series of 28 cases of plague which occurred in this village, it is worthy of note that only in four instances did two or more cases occur in the same house. These cases are:

Cases 4 and 5 in house 92 building 11 Block IV.

Cases 19 and 26 in house 28 building 5 Block I.

Cases 14 and 18 in house 134 building 20 Block VI.

Cases 24 and 25 in house 134 building 12 Block VII.

The first two cases (4 and 5) occurred in the area in which a plague

epizootic was present. They were attacked almost simultaneously. From what has been said it seems unlikely that cases 19 and 26 acquired their infection in the house in which they lived. Cases 14 and 18 both probably derived their infection in the mixing room of the mill at which they worked and not in the house in which they lived. Cases 24 and 25 appear to have contracted their infection in the godown of the mill where the mother, case 24, worked.

In all the houses where plague cases occurred a number of individuals were living in the same room as the sick. In no instance did we get any evidence to show that the sick communicated the disease to their healthy attendants and friends.

Conclusions.

The main conclusions to be derived from this epidemiological study may be summarised under the following heads:

(1) The structure of the buildings and the habits of the people living in them favour a high degree of rat infestation.

(2) The rat infestation of the buildings has no direct relation to the number of inhabitants living in them.

(3) Although a large number of rats, equivalent to nearly two-thirds of the human population, was removed from the village during the year's operations, still a large number remained, the loss evidently being rapidly made good by reproduction.

(4) The plague epizootic in the village was of a very limited character. This might be due, either to the late date in the epizootic period when the disease started, or, in part perhaps, to a considerable temporary reduction in the rat population. New foci of rat infection were possibly started through imported infection; but the disease at this time made no progress among the rats.

(5) From the available evidence it appears that 17 of the cases (61%) acquired their infection outside the village.

(6) There is no evidence to show that the disease spread from man to man when infection was imported into the village by sick persons. Persons living in the same room as the sick did not contract the disease.

V. OBSERVATIONS IN THE VILLAGE OF WORLI.
(Map X with Plate XXXIV.)

As in the other three villages on Bombay Island in which epidemiological observations were conducted, so in Worli elaborate preparations were made for the study of the plague epidemic and epizootic, should the disease break out. We had every reason to expect an epidemic of plague in this village, for it had been smitten by the disease each year for the past nine years. However, as far as plague is concerned, only three events of importance occurred during the year in which the village was under observation.

Worli village is situated on a narrow peninsula on the north-western shore of Bombay Island. The inhabitants are nearly all fishermen. The buildings, or rather huts, inhabited by these fisher-folk are, for the most part, constructed of rough stones held together by clay or some poor quality of lime. The roof of the huts is generally covered with palmyra palm leaves. A few more substantial buildings are to be found in the village, but the Bombay chawl is unknown. Indeed, the whole features of this village closely resemble those found in any Konkan village, and markedly contrast with the conditions found in Bombay City or those described as existing in Parel village. In connection with the census operations, some details of which are given in Table XVII, we divided the village into four blocks. It will be seen that the population of the village is 2508 and that the inhabitants live in 593 houses, situated in 388 separate buildings. These figures give an average of four inhabitants per house and a little over six per building.

TABLE XVII.

Showing Houses, Buildings and Population of Worli Village.

Block No.	Building No.	Houses	Population	Remarks
I	88	119	573	Average no. of inhabitants per building :—6·5.
II	94	173	665	“ “ “ “ house :—4·3.
III	83	137	642	
IV	123	164	628	
Total	388	593	2508	

A detailed study was made of the rat population of the village. This was done by placing rat traps in the buildings in rotation according to the census enumeration, about 230 traps being set each week. Table XVIII shows the number of rats caught alive and found dead each



Warli village.



Inhabitants of Warli.

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TABLE XVIII.

Weekly summary of rats caught alive and found dead in Wortli Village.

Date	Alive					Total	Dead					Plague infected
	rattus	decumanus	Nesokia	Mice	Musk rats		rattus	decumanus	Nesokia	Mice	Musk rats	
22nd to 26th Nov. '05	215	0	1	0	50	266	0	0	0	0	0	0
27th Nov. to 3rd Dec. '05	155	0	1	8	90	254	0	0	0	0	0	0
4th to 10th Dec. '05	128	0	0	0	33	161	0	0	0	0	0	0
11th to 17th "	159	0	0	0	53	212	0	0	0	0	0	0
18th to 24th "	103	0	0	0	44	147	0	0	0	0	0	0
25th to 31st "	96	0	0	0	43	139	4	0	0	0	0	0
1st to 7th Jan. '06	90	0	0	0	59	149	1	0	0	0	0	0
8th to 14th "	125	0	0	0	66	191	0	0	0	0	0	0
15th to 21st "	98	0	0	0	23	121	0	0	0	0	0	0
22nd to 28th "	74	0	0	0	0	74	0	0	0	0	0	0
29th Jan. to 4th Feb. '06	43	0	0	0	22	65	0	0	0	0	0	0
5th to 11th Feb. '06	57	0	0	0	16	73	0	0	0	0	0	0
12th to 18th "	41	0	0	0	32	73	0	0	0	0	0	0
19th to 25th "	45	0	0	0	4	49	0	0	0	0	0	0
26th Feb. to 4th March '06	41	0	0	0	2	43	2	0	0	0	0	0
5th to 11th March '06	29	0	0	0	3	32	0	0	0	0	0	0
12th to 18th "	39	0	0	0	0	39	0	0	0	0	0	0
19th to 25th "	24	0	0	0	0	24	0	0	0	0	0	0
26th March to 1st April '06	20	0	0	0	0	20	0	0	0	0	0	0
2nd to 8th April '06	33	0	0	0	0	33	1	0	0	0	0	1 rattus
9th to 15th "	20	0	0	0	0	20	0	0	0	0	0	0
16th to 22nd "	41	0	0	0	0	41	1	0	0	0	0	0
23rd to 29th "	49	0	0	0	0	49	0	0	0	0	0	0
30th April to 6th May '06	50	0	0	0	5	55	0	0	0	0	0	0
7th to 13th May '06	34	0	0	0	9	43	1	0	0	0	0	0
14th to 20th "	43	0	0	0	6	49	0	0	0	0	0	0
21st to 27th "	49	0	0	0	2	51	0	0	0	0	0	0
28th May to 3rd June '06	21	0	0	0	10	31	0	0	0	0	0	0
4th to 10th June '06	16	0	0	0	4	20	0	0	0	0	0	0
11th to 17th "	52	0	0	0	0	52	0	0	0	0	0	0
18th to 24th "	59	0	0	0	10	69	0	0	0	0	0	0
25th June to 1st July '06	30	0	0	0	2	32	0	0	0	0	0	0
2nd to 8th July '06	27	0	0	0	2	29	0	0	0	0	0	0
9th to 15th "	21	0	0	0	2	23	0	0	0	0	0	0
16th to 22nd "	18	0	0	0	7	25	0	0	0	0	0	0
23rd to 29th "	28	0	0	0	5	33	0	0	0	0	0	0
30th July to 5th Aug. '06	35	0	0	0	7	42	0	0	0	0	0	0
6th to 12th Aug. '06	18	0	0	0	7	25	2	0	0	0	0	0
13th to 19th "	27	0	0	0	5	32	4	0	0	0	0	0
20th to 26th "	14	0	0	0	0	14	0	0	0	0	0	0
27th Aug. to 2nd Sept. '06	22	0	0	0	0	22	0	0	0	0	0	0
3rd to 9th Sept. '06	43	0	0	0	2	45	0	0	0	0	0	0
10th to 16th "	46	0	0	0	8	54	0	0	0	0	0	0
17th to 23rd "	54	0	0	0	4	58	0	0	0	0	0	0
24th to 30th "	22	0	0	0	1	23	0	0	0	0	0	0
1st to 7th Oct. '06	49	0	0	0	0	49	0	0	0	0	0	0
8th to 14th "	33	0	0	0	0	33	0	0	0	0	0	0
15th to 21st "	9	0	0	0	0	9	0	0	0	0	0	0
22nd to 28th "	38	0	0	0	4	42	0	0	0	0	0	0
29th Oct. to 1st Nov. '06	25	0	0	0	0	25	0	0	0	0	0	0
Total	2608	0	2	8	642	3260	16	0	0	0	0	1 rattus

week; Table XIX gives the number of *M. rattus* trapped each fortnight, the number of traps set to capture these rats and, calculated from these figures, the number of rats caught for 100 traps set. The tables show that 2608 *M. rattus* were caught alive during about one year's operations. This number, it will be seen, is larger than the total human population of the village. In spite of the capture and destruction of so many rats, still a considerable number remained in the village at the end of the operations. If the rats caught may be regarded as

TABLE XIX.

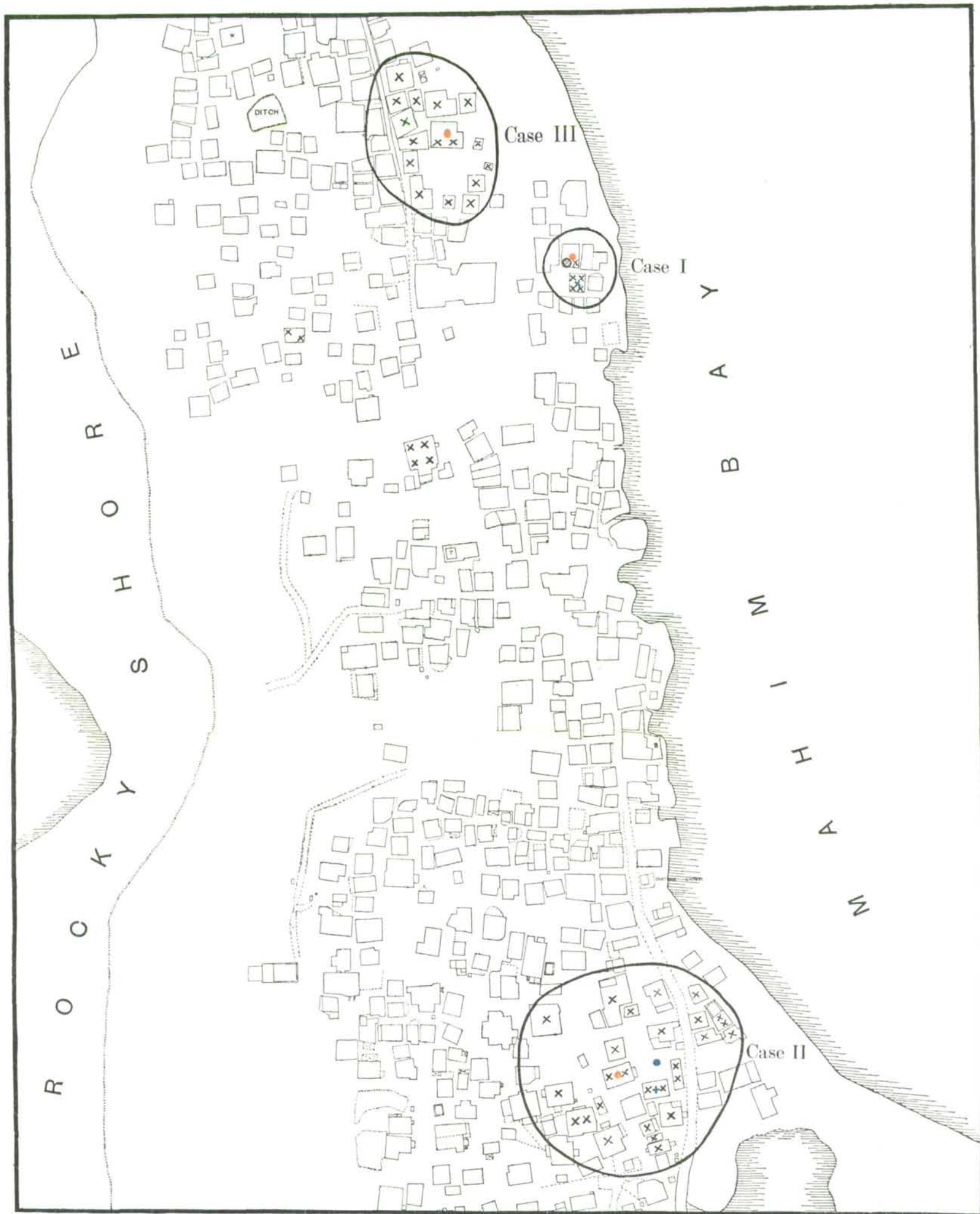
Date	<i>rattus</i> caught	Traps set	No. of rats per 100 traps
22nd Nov. to 3rd Dec. '05	370	526	70
4th to 17th Dec. '05	287	590	49
18th to 31st ,,	199	577	35
1st to 14th Jan. '06	250	684	31
15th to 28th ,,	172	702	25
29th Jan. to 11th Feb. '06	100	447	22
12th to 25th Feb. '06	86	537	16
26th Feb. to 11th March '06	70	351	20
12th to 25th March '06	63	398	16
26th March to 8th April '06	53	267	20
9th to 22nd April '06	61	378	16
23rd April to 6th May '06	99	540	18
7th to 20th May '06	77	554	14
21st May to 3rd June '06	70	483	15
4th to 17th June '06	63	471	13
18th June to 1st July '06	89	472	19
2nd to 15th July '06	48	401	12
16th to 29th ,,	46	480	10
30th July to 12th Aug. '06	53	308	17
13th to 26th Aug. '06	41	308	13
27th Aug. to 9th Sept. '06	65	306	21
10th to 23rd Sept. '06	100	477	21
24th Sept. to 7th Oct. '06	71	443	16
8th to 21st Oct. '06	42	308	14
22nd Oct. to 1st Nov. '06	63	376	17
Total	2608		

a fair index of the rat population it would appear that at the end of the year's operations the rat population of the village was reduced to about one quarter of the original population, that is to say, whereas in the first month of trapping 60 rats were caught per 100 traps set, in the last month only 15 rats were caught per 100 traps set. Table XIX may be compared with the similar table (X) made for Parel. In the case of this latter village the rat population after persistent trapping appeared to

MAP X

WARLI

Shows three cases of plague and events
connected therewith



WARLI

Shows three cases of plague and events connected therewith

Scale 100 feet to five-eighths of an inch

Conventional signs used

- X Guinea-pig placed in house
- ⊗ Guinea-pig became plague infected
- Human plague case
- Plague infected rat
- + Dead rat found but not examined

be reduced to about one half of the original population. The number of traps set in the latter half of the operations in Parel was, however, considerably curtailed and the total number of traps set was smaller than in Worli, the figures being 9391 and 11,390 respectively.

Five months after ceasing operations in Worli the villagers appealed to us to continue the routine setting of traps. They recognised that during the operations the rat population was considerably reduced, but after ceasing the work for five months the rodents had again become a perfect pest¹. The fecundity of *M. rattus* is so great, that it is obvious that nothing but extensive and persistent efforts at their destruction can materially reduce their numbers in any village.

The complete absence of any sewage system in Worli is associated with the complete absence of *M. decumanus* from the village. Only two *Nesokia bengalensis* were captured. The number of mice caught was very small, probably owing to the fact that the rat traps used in this village permitted of their escape more readily than those used in Parel village.

The number of dead rats found and examined by us was only 16. Of this number only one was plague infected. Of the 2608 *rattus* captured alive, none were plague infected.

We are now in a position to consider the three events of importance in connection with plague to which we referred in the early part of this paper. These events we may detail under the names of the patients associated with them, viz.

- I. The case of Jankibai.
- II. The case of Bhagri.
- III. The case of Maribai.

I. *The case of Jankibai.*

Jankibai was a woman close on 70 years of age who lived in Worli. She left the village in perfect health on the 14th February to attend the funeral of her nephew, Laxuman Narayan, who lived at 94-96 Sonapur Street in Bombay City. Motiram Ramji, another relative of the old woman, was ill with plague in the same house in which Laxuman had died. After the funeral Jankibai remained on at Sonapur Street nursing this latter patient. Dead rats had been found in the house at Sonapur Street, and many dead rats, found in the neighbourhood at this time, were proved by us to be plague infected. Motiram died on the 18th February. Jankibai in the meanwhile had developed fever. She

¹ This observation suggests that the rat population was really materially reduced by the trapping and not merely rendered more cautious.

came back to Worli on the 19th suffering from plague, as evidenced by high fever and a well-marked bubo in the groin. She went to a house in Block I, building No. 54, where we saw her on the 21st February. On visiting this house we observed that the building opposite, namely building No. 53, was vacant. On inquiring we learned that the inhabitants had found a dead rat in this house on the 11th February, and had in consequence vacated and were living in an adjacent temporary shed.

Two days after Jankibai came to the village, we placed two guinea-pigs in her house and four guinea-pigs in the vacated house opposite. The guinea-pigs were kept in the houses from 21st to 24th February, being examined for fleas on four occasions. The two guinea-pigs in Jankibai's house gave eleven rat and four cat fleas. The four guinea-pigs in the house in which the rat had been found gave two rat fleas, eleven cat fleas and one *Sarcopsylla*. One of the two guinea-pigs which had been placed in Jankibai's house after isolation in the laboratory died of plague on the 9th March. All the other guinea-pigs remained healthy.

Jankibai's house evidently harboured infection, whereas in the house opposite, from which the inhabitants had fled owing to the finding of a dead rat, we failed to discover infection. The cause of death of this rat could not be ascertained. The inhabitants of Worli are so strongly impressed, after bitter experience, with the relation that exists between the finding of a dead rat and the later development of human plague cases, that during the plague season from January to May the finding of a dead rat causes alarm. The inmates of the building, in which the rat has been found, generally vacate it and live in temporary quarters adjacent to their home. The finding of a dead rat at any other season would be regarded with indifference. In addition to the above instance, on three other occasions we found that the inhabitants had vacated their homes because a dead rat had been found. Although the rats on these four occasions were not examined by us, having been disposed of or removed by a kite or cat, we placed guinea-pigs in the vacated buildings. In no instance, however, did any of these guinea-pigs become infected with plague. The four buildings are shown on Map X, the rats being indicated by green dots and the guinea-pigs, which were placed in the houses, by black crosses. On several other occasions before the events we are now considering, rats which had been found dead were examined by us, but were found not to be infected with plague. Moreover, the examination of 1343 rats caught alive up to this time, did not reveal the existence of plague among the rats of the village.

Taking all the facts into consideration it seems to us that the guinea-pig which contracted plague in Jankibai's house probably derived its infection from infected fleas imported by Jankibai from Sonapur Street in Bombay City. This case closely resembles one recorded in the account of our observations in Parel village. In this instance, it will be remembered, another such woman, coming from the city, appeared to have brought infected fleas to that village (Case 1; Parel village).

For some time after this no event of importance in connection with plague occurred in Worli. About the end of March plague broke out in the fishing village of Sewri, situated on the eastern side of the island. Some of the inhabitants of this village migrated to Worli where they had relations and friends living. We placed guinea-pigs in two of the houses in Worli, in which the Sewri people were residing. These guinea-pigs, however, remained healthy.

II. *The case of Bhagri.*

On the 29th of March we received information of a second case of plague in Worli village. The patient was a schoolboy, named John Domenick Bhagri. He attended a school in the Dadar district of Bombay. As the parents of the lad assured us that no rats had been found dead in their house, we visited the school and obtained the following history from the headmaster. A dead rat had been found in a class room of the school on the 23rd March. Bhagri, however, had not been in this room. On the morning of the 26th March, when the boys were playing on the playground, one of them saw a dead rat lying on the ground. He shouted to Bhagri "Kick it out"; which instruction Bhagri immediately proceeded to carry out. On the following day Bhagri went to school as usual, but in the afternoon on account of feeling unwell had to ask leave to go home.

Bhagri's condition precluded our obtaining confirmatory evidence of this story from himself, but some of the schoolboys we saw vouched for its truth. On our visiting Bhagri at his home on the 2nd April we noticed that the next house had been vacated, and on inquiry ascertained that a dead rat had been found in it on the 20th March. On the same morning, namely 2nd April, we found a dead rat lying on the road close to Bhagri's house. This rat on examination was proved to be plague infected.

Two hypotheses may be brought forward in connection with the question of where Bhagri became infected:—(1) it is possible that he acquired the disease at the school on or about the 26th March and

carried with him to his home infected fleas, which conveyed the disease to the rat we found on 2nd April; or (2) it is possible that he derived his infection in the village from an epizootic of plague, which was evidenced in the dead rat found on the 20th March and again in the rat proved to be plague infected and found by us on the 2nd April.

With the object, if possible, of getting further evidence on this question we carried out some guinea-pig experiments.

On the 2nd April 25 guinea-pigs were placed in 21 houses surrounding Bhagri's house, while at the same time two guinea-pigs were placed in Bhagri's own house. The guinea-pigs were left in the houses for a fortnight. They were then returned to the laboratory. All of them remained healthy. It is probable, therefore, that no epizootic existed amongst the rats in this neighbourhood, as our experience in Sion village had shown us that experiments done with guinea-pigs placed in houses in this manner are a very delicate test of the existence or not of plague amongst the rats. It, therefore, appears likely that Bhagri obtained his infection at the school, possibly when he kicked the dead rat, and that the rat found by us acquired its infection from fleas imported to the village by Bhagri. A very similar experience has been recorded by us in connection with Wadhala village. In this case it appeared probable that coolies, employed by the Commission and who frequently came in contact with infected rats, conveyed the disease to a single rat which was found dead close to their house.

Bhagri died on the 5th April. No other case of plague occurred in this part of the village.

III. *The case of Maribai Anton.*

We have now to record the last case of plague which occurred in Worli. Maribai Anton lived in Block I, building 70. She had always lived in the village and was not in the habit of leaving it, except for a day once a fortnight, when she visited Mahim or Sewri to sell fish. She returned from one of these visits to Sewri feeling ill on the 28th March. She developed a femoral bubo and died of plague on the 3rd April. No rats had been found dead in her house or in any of the adjoining houses. On the 4th April two guinea-pigs were placed in Maribai's house and one in each of fifteen houses in the neighbourhood (*vide* Map X). The guinea-pigs were allowed to remain in these buildings for 10 days and were thereafter isolated in the laboratory. They all remained healthy. It is probable, therefore, that Maribai acquired her infection outside the village. We know that she had visited Sewri, which was at this time badly infected; but if she became infected there, the incubation period

of the disease must have been less than 12 hours. Such a short incubation period in connection with plague has been noticed by others.

Summary and Conclusions.

(1) Worli village is badly infested with rats, practically all *M. rattus*.

(2) Persistent trapping for one year appeared to reduce the rat population to approximately one quarter of the original number.

(3) Three cases of plague which occurred in the village were investigated. It is probable that these three cases all contracted the infection outside the village.

(4) In two instances there is evidence which points to infection having been introduced in the clothing or persons of people, and of this spreading in one instance to a guinea-pig, and in the other instance to rats.