XXXVI. OBSERVATIONS ON PLAGUE IN BELGAUM, 1908—1909.

I. General description of Belgaum district.

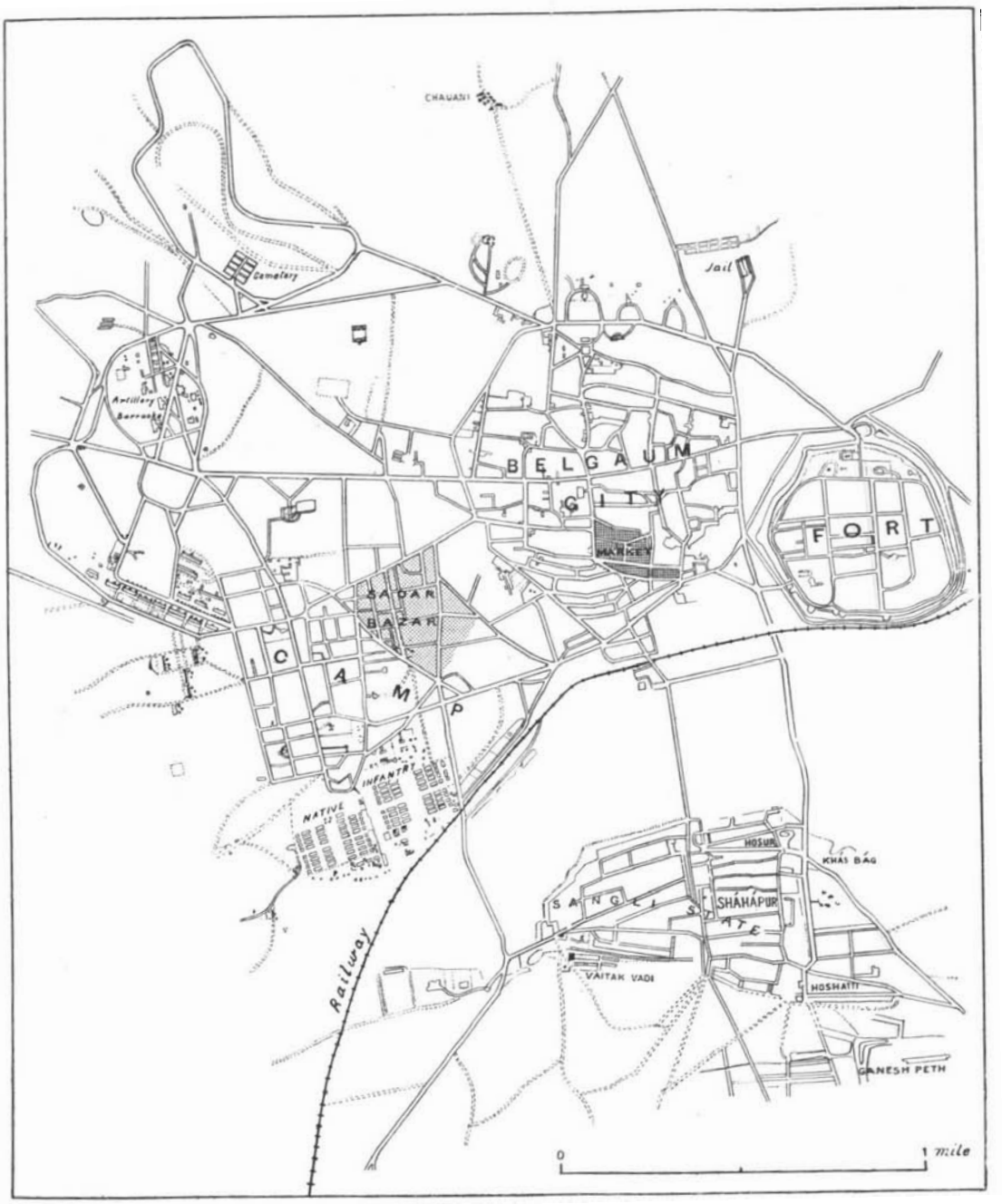
(*a*) *General description and geographical position.* Belgaum is a small town and military cantonment situated in the southern division of the Bombay Presidency, 75 miles inland from the western sea coast of India. It is situated 15° 51′ N. and 74° 31′ E. It lies on a plateau 2500 feet above the sea level on the northern slope of a water-course. The town is built on laterite which lies upon Deccan trap. The country round is fertile and well wooded.

Belgaum cantonment is a military station of some importance. It is the headquarters of a brigade in the Poona Division of the Southern Army. It has a garrison of four battalions of infantry and a battery of field artillery. The cantonment is divided into two portions, the Camp and the Fort. The Camp contains the lines of the four regiments and the battery and the officers' bungalows. The Sadar Bazaar is in the Camp on the side adjoining Belgaum city.

The Fort is roughly circular in outline with a diameter of 1000 yards; it is of considerable antiquity, being reputed to be about four hundred years old. It is surrounded by a deep moat. In the Fort are some twenty bungalows. With the exception of officers' servants it has no native population.

Belgaum city is a small town of considerable importance. It is the headquarters of the Belgaum District, a district covering 4649 square miles with a population of nearly a million people. The city lies between the two portions of the cantonment, viz. the Fort on the east, and the Camp which extends along the western face of the town. It is roughly elliptical in outline and abuts on the Southern Mahratta Railway line which helps to form its southern boundary. The longest axis of the city north and south is about one mile, the shortest 1300 yards. South of the railway line, half a mile distant from Belgaum, is the small town of Shahapur. Shahapur belongs to the Sangli Native

MAP I



BELGAUM CITY AND ENVIRONS

N.B. The "Sadar Bazar" is marked in light hatching. The "Market" is marked in darker hatching

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State. Hosur, Khasbag, Hoshatti and Vaitak-Vadi which geographically are portions of Shahapur are suburbs of and belong to Belgaum (vide map No. I). Juna Belgaum and Vadgaon belong to the Kurundwad Native State.

(*b*) *Climate.* Belgaum being only 75 miles from the sea and on the summit of the western Ghauts is exposed to fresh sea breezes that render its climate very equable. For descriptive purposes the year is best divided into:

(1) *The cold dry season* lasts from mid October to the end of February. The minimum temperature recorded in this season of the year is about 52° F. with a mean daily temperature about 70° F.

(2) *The hot dry season* follows the cold dry season and ceases with the advent of the monsoon early in June. The maximum temperature even in this hot season only occasionally reaches 100° F. and rarely exceeds this. The mean daily temperature ranges round 80° F. The nights are cool and pleasant. Heavy showers attended with the easterly winds, thunderstorms and hailstorms are of frequent occurrence in April and May.

(3) *The wet season* lasts from early June till about the middle of October. As would be expected from its position Belgaum derives full benefit from the south-western monsoon which is very constant in this part of India. The average rainfall is 50 inches most of which falls in the wet season. During 1908 the total rainfall was 47·91 inches distributed as follows: March ·09, April 1·20, May 1·57, June 5·91, July 23·69, August 10·76, September 3·74, October ·83 and November ·12. It will be noted that nearly half the total rainfall fell in July. The rainfall of August, September and October was below the average for these months, that of July in excess of the average. The hygrometric curve closely follows the rainfall curve. We shall have occasion to discuss hygrometric variations when describing their effect on the seasonal prevalence of the rat flea (vide Chart No. II).

(*c*) *Population.* The population of Belgaum city according to the census returns of 1901 was 26,237. This number included the suburbs of Belgaum, the population of which was returned as 3803. The population includes Mahrattahs, Brahmins, Mahomedans, Lingayats, Jains and Mahars in this order of numerical superiority. Mahratti is the language most commonly spoken. Canarese is a dialect used by the Lingayats, Jains and Mahars.

The population of Belgaum cantonment was returned as 10,641. This number included all troops and followers. The figure is now

somewhat too low. The only congested area in the cantonment and the only portion of it that we shall have occasion to consider in this report is the Sadar Bazaar Camp. The Sadar Bazaar covers an area of thirty-eight acres and has a population of three thousand five hundred[1].

Shahapur has a population of 9071, of similar constitution to that of Belgaum city.

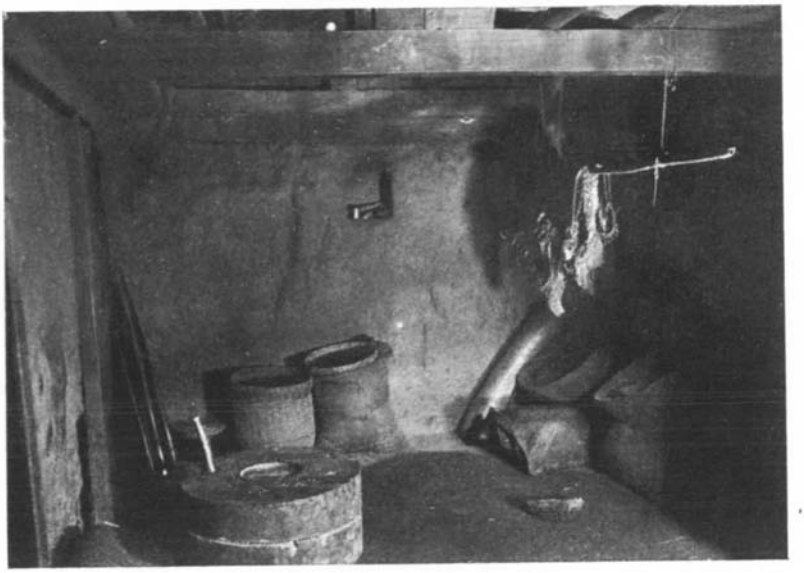
(*d*) *Occupation, industries and trades, etc.* The population of Belgaum is for the greater part an agricultural one. Cotton weaving with hand looms is the chief industry both of Belgaum and Shahapur. A certain amount of silk spinning is also carried on. Copper and brass work gives occupation to a limited number of people. The most important articles of trade are salt, tobacco, dried fish, cocoanuts and coir which are imported by road from the coast, chiefly Vengurla. Grain of all kinds, tobacco, mollasses and sugar are brought in from the country round. There is a considerable trade in cattle.

There is a weekly market held on Saturdays, at which the townsfolk and villagers living within a radius of ten miles, or even more, obtain their supplies. A weekly market, an institution that is common to all towns of any size in the district, is probably of considerable importance as a factor in the dissemination of plague. To this point we shall have occasion to again refer. The market itself is situated near the centre of the town. Grain is here stored in large godowns. Each Saturday sees the market thronged with a vast concourse of people intent on disposing of their wares or laying in a supply of stores.

Most of these remarks about the inhabitants of Belgaum city apply equally to those of Shahapur. Here too there is a weekly Saturday market run on the same lines as, though on a smaller scale than, the Belgaum market.

(*e*) *Construction of houses.* The common type of house in Belgaum is well shown in the accompanying illustrations (Plates IX and X). With but few exceptions the houses are single-storied dwellings. Nearly all are built of mud. The outer walls are from one to two feet thick. Most of these houses are raised on plinths of varying height. These plinths are, like the houses, built of mud but the majority are faced with stone. The stones are plastered together with mud except in a few of the better class buildings. The floors are of mud or beaten down earth covered with a layer of cowdung. The roofs are of country tiles resting on several layers of interlacing bamboos, the whole being supported by rough wooden beams. Many of the houses

[1] Our own census July 1909.



Interior of a typical room in Belgaum: the bags etc. contain grain.

Other end of same room: the large "kangi" and sacks contain grain.

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Corner of Belgaum market, showing native shops.

A native house of the poorer class in Belgaum.

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boast a verandah, but it frequently happens that the verandah, where it once existed, has been closed in by bamboo matting or other material to form an additional living room. Windows exist in a fair proportion of houses, but even when present they are often boarded in, or closed up with piles of stores or rubbish, so that it may be said that windows, functioning as such, are almost non-existent except in the houses of the fairly well to do. These houses of one, two, three or occasionally four rooms are nearly all dark dingy dwellings, the door being the sole source of air and of what little light succeeds in penetrating into their dim recesses. Chimneys there are none. The smoke escapes as best it may through the tiled roof. For all this many of the houses appear to be not badly ventilated, gaps between adjacent tiles of the roof forming efficient outlets for the vitiated air. Nearly every house contains its store of grain ; the grain is stored in the living rooms, often in sacks, frequently in cylindrical receptacles made of bamboo matting. Both of these methods of storing grain are illustrated in the accompanying plates. In many houses there is a platform erected six or seven feet high, made of bamboos and supported on bamboo uprights, which serves as a convenient place for storing fodder, stores and rubbish. Not infrequently cattle share with their owners the shelter of these humble abodes. Overcrowding in some of these houses is appalling. The worst instance of this that we met with was in the case of a very poor house in Shahapur. It was a house of three fairly large rooms and a verandah. It was occupied at the time of our visit by twelve adults, three children, four buffaloes, six bullocks, a goat, a dog, a cat and three fowls[1]. This is an extreme case but instances of a state of affairs nearly as bad are far from uncommon. There are of course houses of a vastly superior type to the picture we have drawn of a typical Belgaum house but they are comparatively few in number and with them at present we have no concern. The houses of the poorest classes again are merely single-roomed mud huts with a tiled roof. The inhabitants of these dwellings sleep on the floor. Charpoys (beds) so common in the Punjab even amongst the poor classes are very rarely seen in the houses of the poor and lower middle classes of Indians in this part of India.

The houses with the exception of a few boxes boast no furniture. Cooking is done in one of the living rooms of the house. Wood, or amongst the poorer classes cowdung cakes, is the fuel by means of which all cooking is carried out.

[1] On the abundance of animals see Appendix p. 478.

We have at least said enough to demonstrate how admirably suited a typical Belgaum house is to the requirements of the rat population. Shelter and food there are in abundance and usually freedom from molestation.

(*f*) *Sanitation and water supply, etc.* The sanitation of Belgaum city is in the hands of a Municipality. Shahapur has a Municipality of its own. The cantonment authorities are responsible for the sanitation of the Sadar Bazaar Camp.

Most of the houses in Belgaum city have latrines of their own. These are cleaned at night by municipal sweepers and the filth carted out to trenching grounds a mile or so from the city. A similar method of refuse disposal was till recently carried out in cantonments. Incinerators are now used to a certain extent.

The sanitary arrangements in Shahapur are more primitive. Here the poorer classes go out to the surrounding fields for purposes of nature. About half the houses of Shahapur have cesspits. No attempt is ever made to clean these and the cesspit is often in dangerous proximity to the well which serves as the source of the drinking water for the establishment.

The water supply is entirely from wells. Many houses have small wells of their own. In Belgaum city there are in addition several well-constructed large municipal wells.

Scavenging of the streets is done by sweepers employed by the Municipality. Along either side of most of the roads immediately in front of the dwellings runs an open drain, made of stones plastered together with mud varying in depth from 1 to 2 feet. This serves the purpose of carrying off storm water, as well as in too many cases forming the receptacle for street and house sweepings. As Indian country towns go, however, Belgaum is comparatively clean and well kept. There are parts of the town, however, that are very dirty. There is a sufficiency of open spaces in many parts of the town. In others the houses are sadly crowded together. In Belgaum city there are approximately 4650 houses which gives an average of a little over five people to a house.

(*g*) *Reference to former epidemics of plague. Their great though decreasing severity and constant seasonal prevalence.* A short account of the epidemics of plague that devastated Belgaum in the years 1897—1906 was given in a former number of these Reports (vide *Journal of Hygiene*, vol. VIII. pp. 270—277 and charts). It will be remembered that the seasonal prevalence was remarkably constant (see Table IV):

excluding the year in which plague was introduced (1897) all the epidemics, with the exception of one, commenced in July or August, reached their maximum severity about October, and declined in December and January. How severe some of these early epidemics of plague were, will be gathered from the fact that as many as 300 cases have been reported in a week at the height of the epidemic and this in a town with only a population of 26,000 people. The total number of deaths from plague in the Belgaum municipal area and cantonments since plague first started in 1897 is 12,108.

The earliest epidemics were the most severe; since when each epidemic, except that of 1901—02, was milder than its predecessor till 1906 when there was no epidemic at all. Plague reappeared in Belgaum in September 1907. This was a comparatively mild outbreak. There were 257 reported cases between September 1907 and May 1908 with 159 deaths distributed as follows:

September	6
October	23
November	65
December	60
January	36
February	39
March	18
April	10
May	0
	257

This small outbreak which cannot be compared in severity with its predecessors started later, reached its height a little later and declined very gradually, cases persisting into April.

When observations were started May 11th, 1908, Belgaum was apparently entirely free from plague.

(*h*) It will be convenient here to discuss shortly what prophylactic measures were being taken by the inhabitants against plague when the place came under observation. In Belgaum city a small amount of rat destruction had been carried out in times of epidemic but the scale on which this was done was entirely inadequate. In the cantonments a reward of one anna per rat was being offered. This measure was likewise quite ineffectual and resulted only in the destruction of about four or five rats a day. There was no attempt at any rat destruction in Shahapur. Inoculation was not practised except on a quite inappreciable

scale, the inhabitants being greatly prejudiced against the proceeding. On the appearance of plague a certain number of people vacated their dwellings and went to live outside the city, some in huts specially constructed for the purpose. A still larger number only left their houses when cases had actually occurred in them, *i.e.* too late to be of much practical value, and returned after a short interval. A very small amount of disinfection of infected houses was done by means of pesterine. The patients were, except in the case of the very poor, treated in their own homes.

II. Scope of the enquiry.

In the general introduction the chief reasons have been given why Belgaum was selected as a place about which it was thought desirable to try and obtain information which might help to throw light upon the seasonal prevalence of plague in that district. We stated here that, in the light of our previous experience, climatic conditions in Belgaum appeared at no time of the year to be unfavourable to plague.

The problems that confronted us at the outset of the inquiry were:

(1) What factors especially favourable to plague exist in July and August which are capable of explaining the constant appearance of plague at this season of the year.

(2) What are the factors existing in December, January and February which render this period of the year unsuitable to plague, thus prompting the decline of epidemic.

(3) What happens to plague in the off season. Does it persist in acute form amongst rats, as in Bombay, or in a chronic form, or does it entirely disappear, each epidemic originating with a fresh importation of infection.

We hoped that our observations might incidentally throw additional light on the habits and life history, distribution and prevalence of rats and fleas. We also hoped to learn more about the interesting condition described by us in a previous report as chronic plague of rats.

Description of the methods which were adopted in Belgaum for studying the epizootic and epidemic and the habits of rats and fleas.

Our first task was obviously to make a study of the rodent population of the town and to this end arrangements were made for systematic trapping of the place. Rat examination was commenced on

12th May 1908. It was our first intention to limit our observations to Belgaum town but a little experience soon showed that the near propinquity of the Sadar Bazaar Cantonment and Shahapur rendered their inclusion in the field of our work desirable and necessary.

Work was commenced in Shahapur on the 19th June and in the Sadar Bazaar on the 4th July 1908. An average of 520 traps were set daily, about 80 in cantonments, 80 in Shahapur and 360 in the city (Belgaum proper).

The town of Belgaum is for municipal purposes divided up into twelve wards. Work went on simultaneously in all these wards and endeavours were made to trap the whole town evenly. We thus hoped that each day's catch would represent a fair sample of the rats of the town. The traps were in the charge of coolies who worked under the supervision of inspectors. Each cooly had charge of from 20 to 30 traps.

Account was kept (1) of the number of traps set daily; (2) the number of houses trapped and their addresses; (3) the number of rats caught.

Traps cleaned and rebaited were taken round and distributed each afternoon. The following morning the houses in which traps had been left were revisited and any rats caught collected. When a trap was found to contain rats it was put in a canvas bag, tied up and a label affixed. The label which was filled in by the inspector contained the following information: (1) serial number, (2) the address where the rat had been caught and (3) the number of rats in the trap. The rats thus caught were then despatched to the laboratory for examination. Endeavours were also made to obtain the corpses of any rats that might have been found dead (especially in the plague season) but our efforts in this direction met with very little success. The townspeople did very little to second our efforts, and though occasionally we received information that rats were dying in certain houses or in certain streets it was only on very rare occasions that the corpses of such rats were handed over to members of our rat-catching staff. We had to content ourselves, therefore, with studying the progress of the epizootic by examination of live rats, the number of dead rats obtained being very small indeed. For some reason or other the populace were even averse to confess that a rat mortality was taking place in their houses: on several occasions we found that this was the reason, however, that caused householders to suddenly vacate their houses. Undoubtedly, too, rats may be dying in a house without the inhabitants being aware

of the fact. Rats not infrequently die in their burrows, or under cover of boxes or sacks, or amongst rubbish or even in the roofs of the houses. In one case of plague that we were investigating an intelligent householder volunteered the suggestive information that four or five days prior to the date on which the patient was taken ill, he had noticed maggots falling from the roof of one of the living rooms. He had not seen any dead rats. On the whole people were not averse to taking traps into their houses. There are exceptions, however, and no amount of persuasion on our part could get round their prejudices. This objection to taking in traps was not wholly confined to the Jain community[1] though as was to be expected it was most marked amongst them. It is suggestive that the two roads where we had most trouble in this direction (viz. in Hosur) were more heavily infected with plague than any other portion of the town. The adjacent lanes in Shahapur which were being fairly constantly trapped at the time when Hosur was affected were comparatively free from plague.

On arrival at the laboratory the rats were submitted to examination much in the same way as in Bombay (vide *Journal of Hygiene*, vol. VII. p. 738). The trap was removed from the canvas bag, and trap and bag were at once placed in a tin box, provided with a well-fitting lid, and a removable tray covered with white american cloth. The trap (containing rats) and the bag were then freely sprinkled with chloroform and the box closed. After some minutes had elapsed the box was opened, the canvas bag vigorously shaken over the open box to detach any fleas that may have adhered to the bag, and then the tray and the trap which was resting on it were together removed and taken to the flea counting table. Here the fleas found resting on the tray were collected and counted and each rat examined separately for fleas. Banging the rat vigorously on the table for a minute or so is usually sufficient to dislodge any fleas that remain on the rat, provided that sufficient chloroform has been used. Usually it was found that about one quarter of the total number of fleas was found resting on the tray, the remainder adhering to the rats. The flea counting table was covered with white cloth. Having thus made as accurate a count as possible of all the fleas obtainable from the rats in any one trap the number of fleas was entered on to the trap ticket referred to above.

Another ticket was then made out for each rat. On this was written the serial number of the rat and the number of the trap ticket. The

[1] The Jains have strong religious scruples about taking the life of any animal: even parasitic insects such as bugs are carefully preserved and occasionally deliberately fed.

rat was then weighed, pinned out on a board and dissected in the manner that was described in detail in the account of the work in Bombay. All the information thus obtained was entered on the rat ticket, viz. species, weight, sex, if female whether pregnant or not, if pregnant the number of foetuses, whether healthy or not. If there was anything of interest, or if the rat appeared to be unhealthy, full notes of the condition and pathological changes were made on the back of the card. At the end of a day's work all this information recorded on the trap and rat tickets was entered in a special register.

Early in the work a spleen smear of every rat was made and stained with carbol thionine and examined microscopically. This practice as a routine was afterwards abandoned though it was adhered to in all doubtful cases. The results obtained were not commensurate with the amount of labour involved. The previous experience of the Commission was again confirmed, viz. that in the diagnosis of rat plague macroscopic appearances are, to a trained observer, of greater import than microscopic examination. The microscope was used merely as a confirmatory test in any case of doubt. When there was any further doubt as to the diagnosis cultural and animal tests were also resorted to.

Plague cases in Belgaum are reported to the Municipality. For these reports the Municipality rely on medical practitioners and an inspector who was employed by the Municipality for the purpose of discovering and reporting plague cases.

The Commission received daily notice from the municipal authorities of cases that had been reported to them. In addition they often received early news of cases from members of the rat-catching staff who were constantly employed in every part of the town. In a similar way news of plague cases in Shahapur was received from the Secretary of the Shahapur Municipality. Cases occurring in Sadar Bazaar Cantonment were reported by a Hospital Assistant on special plague duty to the cantonment magistrate who was kind enough to forward such reports to the member of the Commission in charge of the Belgaum work. Many cases, more especially those occurring early in, and on the decline of, the epidemic were verified by the Commission. A few mild cases undoubtedly escaped being reported and in a few instances cases reported as plague had been wrongly diagnosed as plague; but on the whole the information collected as described was accurate enough. From a careful study of deaths from all causes contained in the death registers we have arrived at the conclusion that very few deaths from plague escaped notification.

III. Rats and fleas.

Rats.

The following species were met with in Belgaum:

Mus rattus
Bandicota indica (*N. bandicota*)
Mus musculus
Gunomys varius (*Nesokia bengalenis*)

as well as Musk Rats (*Crocidura coerulea*).

In the period during which the Belgaum observations were being carried out, viz. from 12th May 1908 to June 30th 1909, 39,460 *Mus rattus* were trapped. Of this number 38,957 were submitted to examination in the daily routine in the manner that has been described above. The remaining 503 were kept in stock for experimental purposes.

The other species were in comparison numerically insignificant. They were as follows:—1180 mice, 503 musk rats, 71 bandicoots and 3 *Gunomys varius*. Musk rats are very much more numerous than would appear from the above figures. Many of them were liberated when caught in deference to the sentiments of the Hindu population who hold this animal in high esteem. Its immunity to plague renders it harmless from the plague standpoint. A plague infected musk rat was never found by us in the Belgaum observations.

Mice too are comparatively more numerous than the figures indicate. Our traps were not suitable for mice.

Mus rattus.

This is the common species of house rat in Belgaum as in most parts of India. The type resembles closely that found in the Punjab, Bombay and Poona. It is perhaps a little larger than the Bombay variety and certainly much larger than the Poona *Mus rattus*. The average weight of an adult *Mus rattus* was between 140 and 150 grammes. Three specimens weighing 250 grms. were taken. It is essentially a house rat. It burrows frequently, but more commonly it lives and breeds in the house amongst heaps of rubbish, behind boxes or in the roof. Burrows of *Mus rattus*, however, have been seen in many houses. As will have been gathered from the description given

of a typical Belgaum house, these dwellings leave little to be desired from the rat's point of view.

Breeding. The *rattus* of Belgaum breeds all the year round but to a much greater extent during the first half of the year than the latter half. Approximately the breeding season of *Mus rattus* in Belgaum corresponds with the off plague season. Daily observations were made of the total number of *Mus rattus* examined, the total number of young rats (70 grms. and under) and the total number of pregnant females. The weekly figures are given in the annexed table (Table I). The average number of foetuses in 4841 pregnant *Mus rattus* was 5·4.

Degree of rat infestation. It is difficult to form an adequate idea of the degree of rat infestation of any given place. There are a few facts in this connection, in the case of Belgaum, however, that are worth consideration. During the period of our observations the number of *Mus rattus* caught was slightly in excess of the human population. When allowance is made for houses where the inhabitants refused to take traps, approximately six rats were caught for every house trapped. When trapping operations were started the number of rats taken per 100 traps set was about 32. When the observations ceased this figure had fallen to 16 (see Chart III and Table I). We may assume, therefore, that we had, with the assistance of the plague epizootic, very considerably reduced the rat population. We acknowledge that this gives us little or no idea of the exact rat population but it suffices to demonstrate to what a huge extent the houses were infested with rats. It will be noticed on referring to Table I, that the percentage of young rats was very much higher in May and June 1909 than it was in the corresponding months of the previous year. This indication of more active breeding was perhaps compensatory to the attacks on the rat population made by plague and our trapping operations. (The plague in Belgaum in 1908—09 was a good deal more severe than it was in 1907—08.) In spite of our continued trapping the rat population was apparently on the increase when our observations came to a close (see Table I).

Immunity of Mus rattus to plague. Our main object as we have already mentioned in undertaking observations in Belgaum was to endeavour to throw more light on the subject of seasonal prevalence of plague. With this object in view an endeavour was made to determine whether or not the immunity of the Belgaum *rattus* to plague underwent seasonal variations. Our original idea was to inoculate some 50 *Mus rattus* with plague each week and observe what percentage died of

plague. The difficulties that we encountered were numerous. Among these we may mention the great difficulty we experienced in keeping wild rats alive and well in captivity. We found that when the rat cages became damp, especially in the wet weather, many rats died from unknown causes, so that we had considerable difficulty in determining when a rat actually died of plague. Some rats for example were found dead on the second day after inoculation presenting no symptoms of plague except numerous plague bacilli in the lymphatic gland nearest the site of inoculation. Should such a rat be recorded as having died of plague or would it be more correct to class it with many others which had obviously died from causes associated with the unnatural surroundings in which they were kept? Another important difficulty arose from the impossibility of maintaining throughout a long period a constant test dose of plague bacilli. We started by using the cutaneous method of inoculation. A spleen or liver of a rat or guinea-pig dead of plague was rubbed into the shaven surface of the rat. Using this method we found that very few rats died of plague. Batches of twenty were done without a single plague death. We then tried injecting a high dilution of an emulsion of infected rat spleen in normal salt solution, selecting only those spleens which showed numerous plague bacilli on microscopic examination of smears. We found it impossible by this method to get a uniform dose week by week and our results were most irregular. Altogether we inoculated 264 rats and then abandoned the experiment. The one lesson we learned from the experiment was that the *rattus* of Belgaum appeared to enjoy a very high degree of immunity.

With the object of comparing this immunity with that of the *rattus* of Bombay and Poona, rats were sent from Belgaum and Poona and put into the godowns at Parel along with Bombay rats. Into each godown were put equal numbers of Poona, Bombay and Belgaum rats. Each rat was in a separate cage on the floor of the godown. Into each godown very numerous plague infected fleas were introduced. In all, experiments were done on 270 rats with the following results:

Of 90 Poona rats 24 died of plague.
Of 90 Bombay „ 16 „ „ „
Of 90 Belgaum „ 8 „ „ „

From this experiment it would appear that the Belgaum[1] rat is

[1] It may be worth noting in this connection that in proportion to their populations Belgaum (population 26,000, plague deaths 12,000) has suffered much more severely from human plague than Bombay (about 900,000, plague deaths 167,000).

twice as immune as the Bombay rat and three times as immune as the Poona rat to plague, but it is obvious that the figures are not large enough to warrant any reliable deductions being made from them.

Bandicota indica.

During the year 71 bandicoots were captured. This number does not give an adequate idea of the relative frequency of this rodent but as compared with *Mus rattus* it is certainly rare. The traps that were generally used by us were not nearly large enough to capture bandicoots and the specimens we obtained were caught for us by the townsfolk in large wooden country traps. A reward was offered for every bandicoot brought in.

The bandicoot of Belgaum is a large coarse-furred rat. It is dark grey in colour. It has soft thick fur from which protrude long bristles. Its tail is about equal in length to the length of the body and head combined. It is far bigger than any other species of rat that is met with. We have had several specimens weighing over 1000 grms. A full grown specimen cannot be mistaken for anything else. A very young one might be mistaken on cursory examination for *Gunomys varius*. When our observations commenced the bandicoot was found only in three or four streets on the outskirts of the town. In these streets it was not uncommon. In April, May and June 1909, however, we obtained specimens from various parts of the town. In its habits it is a house rat. Its burrows are usually to be found in the mud floors of a native house, occasionally in the walls. In spite of its enormous size the people do not appear to resent the presence of bandicoots in their houses. One man, whose house harboured a colony of these animals, refused to let us trap them for said he "if we have bandicoots we shall not get plague," a popular but dangerous fallacy as we will presently show. The burrows of the bandicoot are occasionally of gigantic size, far bigger than would appear to be necessary from the size of the animal; they resemble rabbit warrens, and often literally undermine the floors of native houses. The burrowing capacity of the animal is truly remarkable. The amount of damage that it is capable of doing in a single night would appear incredible to any one who had not ocular demonstration of its burrowing abilities. The bandicoot that we have met with in Belgaum is remarkably susceptible to plague—very much more so than the *rattus* of Belgaum which as we have seen possesses a comparatively very high degree of immunity. A full grown bandicoot

on one occasion succumbed in three days to a dose of plague that failed to kill a guinea-pig of considerably less weight. For this reason, and the fact that the animal lives and thrives well in captivity, we have frequently employed bandicoots for laboratory experiments in the place of guinea-pigs to determine the identity of plague-like organisms. In Belgaum as in many other places in the Bombay Presidency there is a well authenticated report that before plague came the bandicoot was the rat most in evidence in every quarter of the town. There was scarcely a house without its colony of bandicoots. With the advent of plague the bandicoot disappeared, or migrated as the report usually has it. Its disappearance can be readily credited, though we have obtained no reliable evidence of migration. Its remarkable susceptibility to plague is quite sufficient to account for its disappearance from Belgaum city. Further report says that until the present year the bandicoot has been conspicuously absent. It is only just beginning to return. This is credible. It has not yet "returned" to Shahapur where it was once equally common; we only obtained two specimens from the cantonment and these were both found dead of plague. The comparative mildness of the last few epizootics of plague would account for the reappearance of the bandicoot.

In this connection it is interesting to note that nearly all bandicoots caught in Belgaum were caught in the off plague season. None were brought in between the end of August and January in spite of a reward of eight annas offered for each one brought in alive. The disappearance of the bandicoot on the advent of plague was also noted in Hindulgar, a small village three miles from Belgaum.

Gunomys varius.

We have only met with three specimens of this rat. All three were caught in a field at some distance from human habitation. It does not occur as a house rat in Belgaum.

Fleas.

The only species of rat flea that we have met with in Belgaum is *Loemopsylla cheopis*. Two specimens of a flea very similar to *Ceratophyllus fasciatus* were found, together with four *L. cheopis*, on a squirrel dead of plague. The former species was never seen on a rat in Belgaum.

The flea infestation of *Mus rattus* in Belgaum is very large, and greater than has been observed in other parts of India where similar observations have been made. There is, too, a very noteworthy seasonal prevalence of fleas. A reference to Charts I, II and III and to Table I will make these points clear. The average number of fleas per *Mus rattus* varied from 3·6 in May to 18·6 in October. During 13½ months 380,678 fleas were counted on 36,890 *Mus rattus* which gives an average for the whole period of 10·3 fleas per rat. The average for *rattus* in Bombay was 3·8, in Dhand 9·1, in Kasel 6·9, in Poona 5·9, and for *decumanus* 8·4 in Bombay.

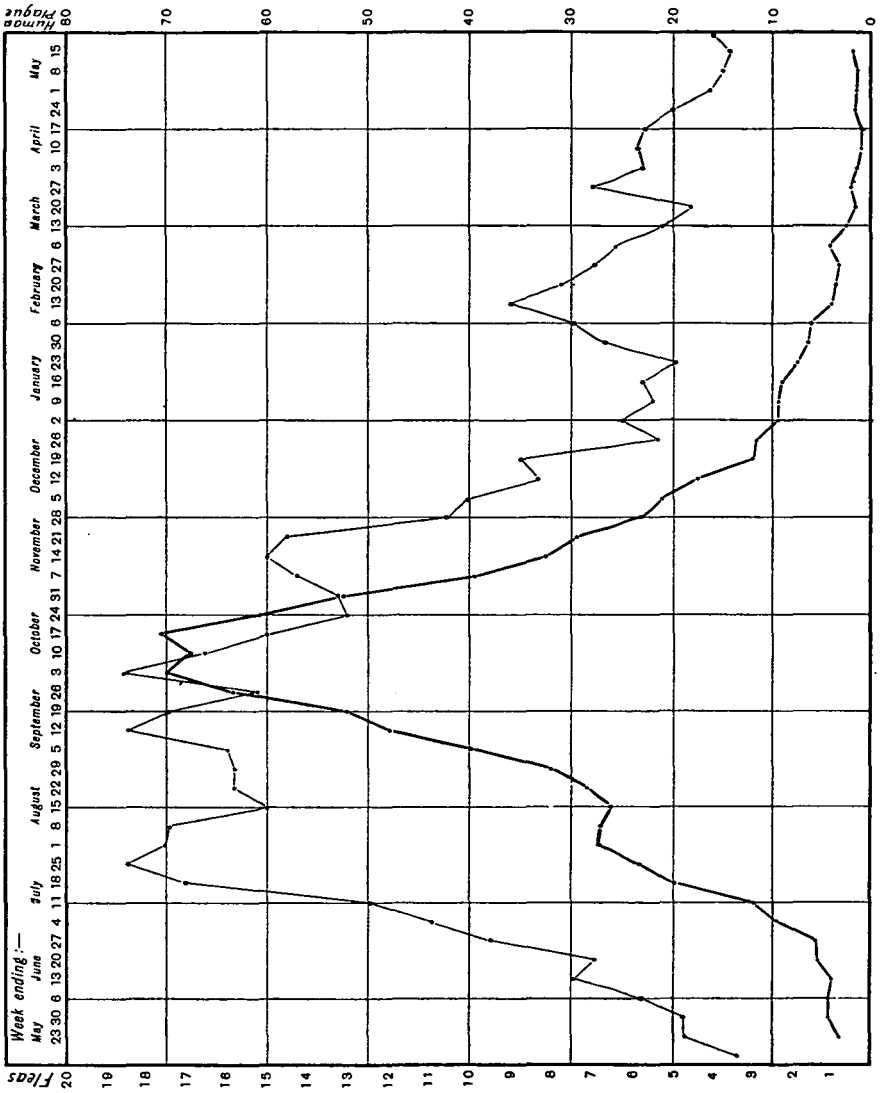
Chart II demonstrates the correlation which appears to exist between flea prevalence and the amount of moisture in the atmosphere. That this is not an absolutely constant correlation is evident from the fact that a similar state of affairs does not hold good for Bombay. We believe it to be, however, a true correlation within limits of temperature, —in other words, provided the mean daily temperature is above 60° and below 80° F. flea prevalence varies directly with the hygrometric conditions of the atmosphere. Speaking generally it would appear from the curve depicted in Chart II that a rise or fall in humidity is followed after an interval of three or four weeks with a corresponding rise or fall in the flea count.

We have not been able to find in Belgaum any host of *Loemopsylla cheopis* other than rats, with the exception of the squirrel found dead of plague referred to above. Goats, dogs, mongooses, civet cats, tame monkeys, turkeys, chickens, ducks, pigeons and bats have been examined for *L. cheopis* without yielding a single specimen.

IV. Plague epidemic and epizootic 1908—1909.

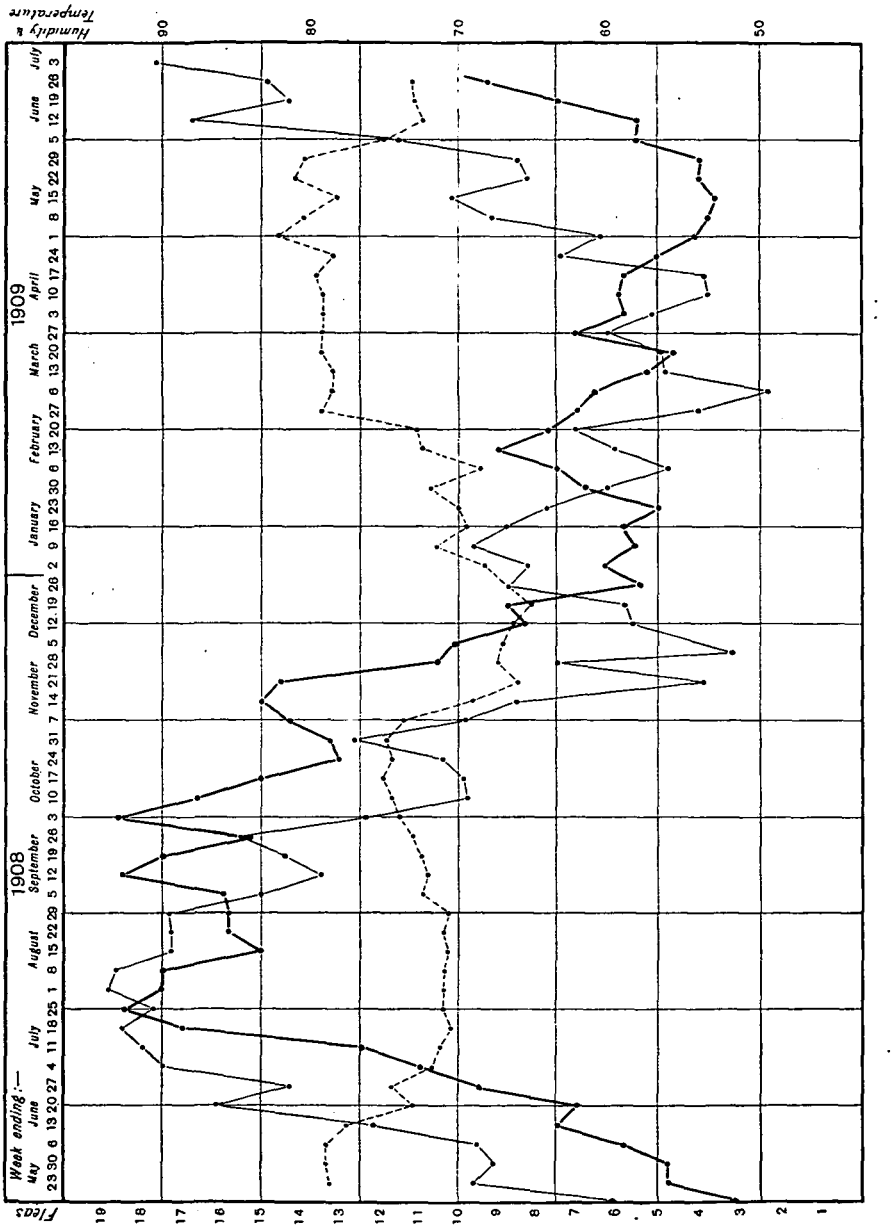
Observations were started in Belgaum on 12th May 1908, that is to say in the middle of the off plague season. At that time careful enquiries elicited the fact that human plague was entirely absent from Belgaum. The last case that had been reported was during the first half of April. May was entirely free from plague but on June 5th a case (Ranubai Laxuman, 4115 Jalgar Gulli) occurred in Belgaum City. The case was seen by us and verified as typical bubonic plague. There was no history of dead rats in the house: in fact the inmates denied the presence of any rats as "several cats frequented the house." Rats must however have been there for a guinea-pig was left for one night in the house, and yielded five *L. cheopis*; none of these contained plague-

CHART I



https://doi.org/10.1017/S0022172400043060 Published online by Cambridge University Press

CHART II



https://doi.org/10.1017/S0022172400043060 Published online by Cambridge University Press

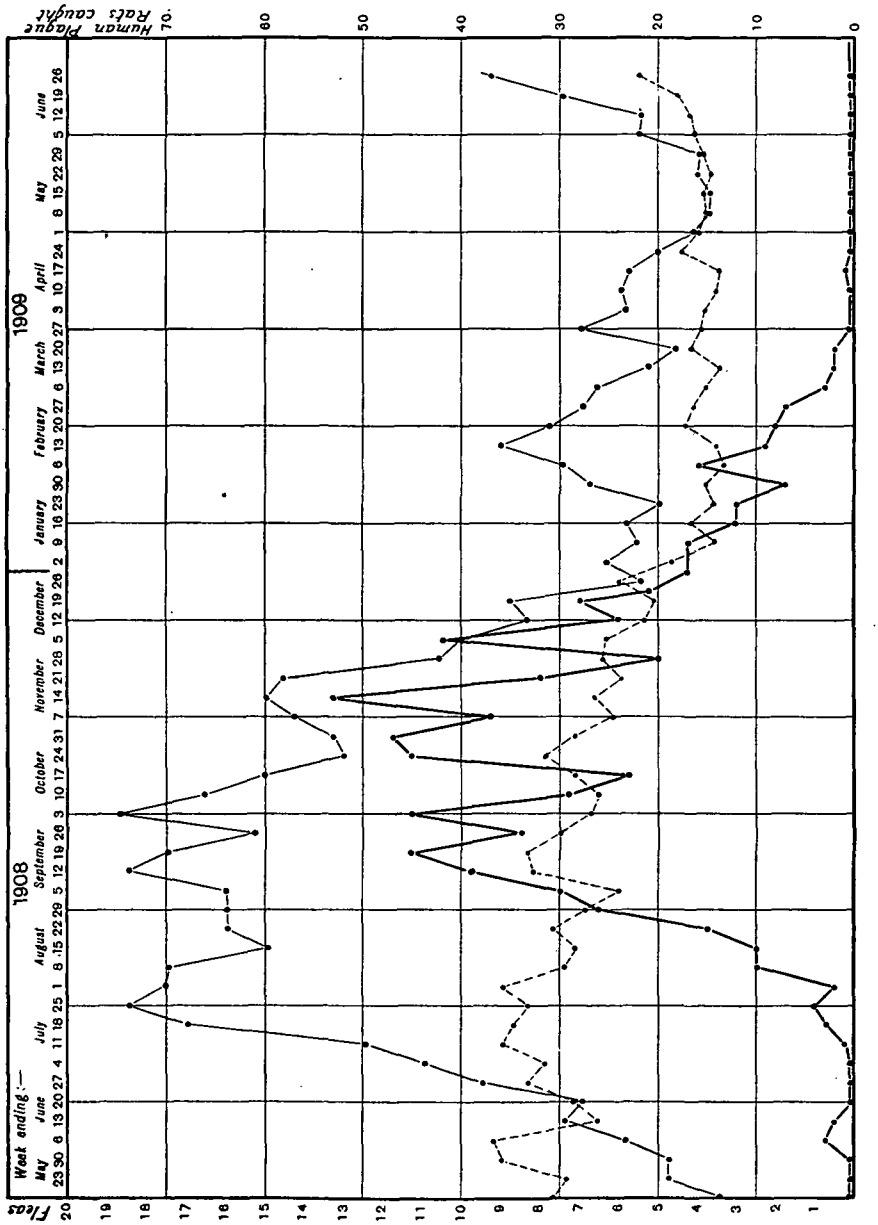
like bacilli and the guinea-pig remained well. The woman died on the 6th June. Two days later a second case occurred in a neighbouring house (Laxumbai Punapa aged 25, 4126 Jalgar Gulli). The patient was the widow of a man who was stated to have died of plague in the latter half of April, her only child dying a day or two after her husband. This case also ended fatally. The diagnosis of this case was confirmed bacteriologically. A virulent culture of *Bacillus pestis* was obtained from the bubo. Here again we could get no evidence of any mortality amongst the rats. On the 10th June the son (Parashuram Laxuman) of case No. I was attacked with plague in a house 4110 Jalgar Gulli into which the people had moved on the death of case I. He died on 13th June. Rats were being caught in adjacent houses at the time these cases were occurring but we could get no evidence of acute rat plague. These three cases formed an isolated outbreak. They were the only cases that occurred in Belgaum City in the month of June. We believe the infection was indigenous: there was no evidence to the contrary. A guinea-pig subsequently lived for a week in 4115 Jalgar Gulli, the home of the first case. It remained well.

In the meantime there had been two cases of plague in the Sadar Bazaar Camp. A mother and her son were both taken ill with plague on 2nd June with symptoms typical of bubonic plague. They both recovered.

These early cases are of importance as they indicate that indigenous plague occurs in Belgaum in the off plague season without assuming epidemic proportions. We shall endeavour to advance a satisfactory explanation of this subsequently.

Nothing further of any interest happened till the 11th July 1908. On this day a rat caught alive and apparently well in 27 Kondappa Street Camp revealed on post-mortem examination macroscopic appearances very suggestive of plague, and was proved to have been plague infected by culture and animal experiment. It subsequently transpired that on the same day a girl aged six years was attacked with plague in a neighbouring house (32 Kondappa Street). This patient died on the 14th July. A guinea-pig left to run in the patient's house picked up seven rat fleas, two of which had plague-like bacilli in their stomach contents. On the 18th July a second plague rat was caught close by in 33 Market Street. A guinea-pig was sent to live in this house in a cage for a week. On its removal only four rat fleas were found on it but the guinea-pig died of typical acute plague on the day following its return to the laboratory. From this time on plague gradually spread and

CHART III



BELGAUM

——— Human Plague Cases (Belgaum City, Suburbs, Cantonment and Shahapur)

—— Number of fleas per Mus rattus

----- Number of rats per 100 traps set

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assumed epidemic proportions. During July six rats caught alive in the Sadar Bazaar were plague infected and on August 1st three rats dead of plague were found in the Police Lines Sadar Bazaar. In Belgaum City seven cases of plague occurred in July. All these cases occurred on the side of the town that adjoins the Sadar Bazaar Camp (see map No. II) and in four cases at any rate the infection was traced with more or less certainty to the latter place. Thus started the 1908—09 epidemic of plague in Belgaum.

It is difficult to speak with any certainty as to the source of the infection that started the epidemic. The following facts are, however, of interesting significance. On July 14th a boy Parasharam Krishna was admitted into the plague hospital suffering from undoubted plague. This was the first case of the epidemic that had occurred in the city. He was brought to hospital from a house in which he had only been living two days. Previously to this he had been living in the Sadar Bazaar where his father had died of what was very possibly plague on the 12th July; his death had, however, been ascribed to other causes. There was a history that this family had recently come from a village some twelve miles away where there was plague. It was certainly from the neighbourhood of their house in the Sadar Bazaar that the epidemic of 1908—09 started.

Comparing the different behaviour of the little outbreak that occurred in June and the one that followed some five weeks later, we note that, whereas the former was self limited the latter rapidly assumed epidemic proportions. A reference to Chart No. I will show that early in June the rat flea prevalence was low and amounted to only five fleas per rat[1]. In the first half of July the flea count gave fifteen fleas per *Mus rattus*.

Meanwhile plague had made its appearance in Shahapur. Two rats caught alive by us on the 14th July were found to be plague infected. Plague was "declared" in Shahapur on the 2nd August. Four or five cases were, however, seen by us during the last week of July. As was stated above our Shahapur observations only started on the 24th June 1908. At that time Shahapur was free from plague. A fortnight previously, however, a case had occurred in Shahapur. It was diagnosed as plague by an experienced practitioner well versed in the symptoms of this disease and we have little doubt as to the correctness of the diagnosis. Two cases occurred in Hosur during the last week of July.

[1] Five fleas per rat however is enough to spread plague in Bombay.

The subsequent history of the epidemic will best be appreciated by a reference to the maps Nos. II—XVII and Chart III. It will be seen how the epidemic started in the Sadar Bazaar Cantonment and gradually spread from there until it spread all over the city. A second early focus of infection was in Shahapur and a third in Hosur (vide maps Nos. III and IV). Hosur consists of two streets on the north side of Shahapur. When plague appeared in Hosur it was not being trapped nor had we previously caught any rats there. Directly plague broke out we commenced to trap the place. The commencement of our work in Hosur, however, being synchronous with a severe outbreak of plague, colour was lent to a rumour that had been started that we were spreading infection with our traps. People with one accord refused to take traps; and the inhabitants of Hosur suffered much more severely from plague than any other part of Belgaum or Shahapur. A glance at maps Nos. IV and V will show how free the streets of Shahapur neighbouring on Hosur kept from plague whilst Hosur itself was badly infected. These neighbouring streets are comparable in every way with the streets of Hosur and in very close proximity thereto. The one point of difference was that Shahapur was being fairly well trapped at the time whilst Hosur was wholly neglected.

The second point of interest that is brought out by the maps is the different behaviour of plague in the Sadar Bazaar Camp and Belgaum City. Plague broke out first in the Sadar Bazaar, reached its height in the first half of September and had completely disappeared by the middle of November. In the city the epidemic started later, reached its height in November and gradually declined, cases persisting until the latter half of March.

The two places lie side by side and free communication exists between them. On the whole the number of fleas per *Mus rattus* worked out the same for both places. The explanation of the difference between the two epidemics appeared to be due to a difference in the rat population, whereas in the Sadar Bazaar in the beginning of July we were able to catch upwards of 40 rats per 100 traps set, in the city we could only catch 30. Two causes apparently contributed to the higher rat infestation of the Sadar Bazaar:—

(1) There was practically no plague in the Sadar Bazaar, during the season of 1907—1908: only five deaths were returned, whereas in the city there were 257 reported cases with 159 deaths.

(2) Our trapping operations began in the city in the middle of May; in the Sadar Bazaar not till the beginning of July.

Although the rat population was higher in the Sadar Bazaar in the beginning of July it very rapidly declined so that by the end of September we were able to take only 15 rats per 100 traps set. The decline in the rat population of the city was much more gradual and it was not until the middle of January that our catches sank to the figure of 15 rats per 100 traps. Two causes were contributary to the more rapid decline of the rat population in the Sadar Bazaar :—

(1) The greater severity of the epidemic and presumably of the epizootic in the Sadar Bazaar than in the city. In the Sadar Bazaar with a population of 3500 there were 112 cases, *i.e.* 3·2 % of the population were attacked. In the city with a population of 23,000 there were 405 cases, *i.e.* only 1·7 % of the population were attacked.

(2) Trapping was carried out somewhat more energetically in the Sadar Bazaar than in the city. This is shown by the fact that in the months July to October 2332 rats were caught in the Sadar Bazaar—a number equivalent to $\frac{2}{3}$ of the human population—whereas in the city 9672 were trapped, considerably less than half the human population. The number of traps used in the Sadar Bazaar per 1000 human population was more than double the number used in the city. (From July to October 34,494 traps were set in the city and 9347 in the Sadar Bazaar.)

Which of these two factors was the important one in bringing the Sadar Bazaar epidemic to a close it is difficult to determine. That the severity of an epidemic is a most important factor in curtailing its duration is illustrated by Hosur. A reference to the maps will show how much more severe the epidemic was here than it was in Shahapur but of much less duration. As we have stated Hosur was untrapped for the most part.

During the epidemic there were 783 cases of plague with 516 deaths which give a case mortality of 65·9 %.

These cases were distributed as follows :—

Belgaum City and suburbs 507 cases, 331 deaths, case mortality 65·2 %.

Sadar Bazaar 114 cases, 80 deaths, case mortality 70·1 %.

Shahapur 162 cases, 105 deaths, case mortality 64·8 %.

As has been stated Hosur was much the worst infected portion of the area under observation. Math Gulli and Basawant Gulli Hosur have a human population of 649 (our own census June 1909). In these two streets alone there were 71 cases and 46 deaths. This is equivalent to saying that if the whole of Belgaum, Shahapur and the Sadar Bazaar had been as badly infected as Hosur there would have been an

epidemic in 1908—09 of 4230 cases instead of 782. We should hardly be justified in assuming that all this difference was due to the fact that fairly energetic rat destruction was going on in all parts of the area under observation except in Hosur, but the assumption is warranted that had it not been for the rat destruction that was going on Belgaum would have passed through a much more severe epidemic than it did.

By the beginning of April Belgaum was again quite free from plague.

Additional evidence to support the view that climatic conditions *per se* in the Belgaum district are never very unfavourable to plague was furnished by an interesting little outbreak of plague that occurred in the village of Hindulgar, which is situated three miles west of Belgaum. Here plague broke out in the middle of April, *i.e.* in the middle of the off plague season. There were in all eight or nine cases, one of which was seen by a member of the Commission on April 21st and verified as plague. There was a history of rat mortality. The epidemic never got a firm hold of the village. Several rats were trapped and examined. The flea prevalence was the same at the time as it was in Belgaum, *i.e.* about five fleas per rat.

The Epizootic.

During the year 130[1] rats were found to be suffering from acute plague. Of this number 110 were brought in alive and 20 dead. Of the latter several were caught alive and died in the trap before arrival at the laboratory. This number of acutely plague infected rats when compared with the number of human plague cases is very small. As has been previously mentioned however our attempts at obtaining the corpses of rats found dead were, for reasons detailed above, unsuccessful. This sufficiently explains why more acute plague infected rats were not found. In addition to the above, a large number of rats in various stages of recovery from plague were met with (see above p. 347). The time and place correlation between human plague cases and acute and resolving plague in rats is shown in the accompanying maps, but our information about the epizootic is obviously very incomplete.

Map No. VI shows that three rats suffering from acute plague were caught in the Fort at a time when plague was absent from the city but

[1] Of the 130 rats which were found suffering from acute plague 18 had no discoverable buboes. Of the remaining 112, 88 had submaxillary buboes (78·5 %), 10 had inguinal buboes (8·9 %), 9 had axillary buboes (8 %); 3 had pelvic buboes (2·6 %), 1 a submaxillary and an axillary bubo, 1 a pelvic and an axillary bubo.

present in the Sadar Bazaar. It was difficult to explain the appearance of this epizootic: it is suggestive, however, that a fortnight before the first plague rat in the Fort was caught, a bag of bran had been brought from a shop in the Sadar Bazaar situated in the centre of the epizootic area. The possibility of conveying rats and fleas in bags of grain cannot be denied. On two occasions in Belgaum, rats were seen escaping from bags of bran when these were being opened and on one occasion a nest of mice was found within a bran bag. As has been said the population of the Fort is almost exclusively European and the small epizootic there was not associated with any human plague cases.

Of the 130 acute plague rats 71 were caught in Belgaum City. Of these, 35 were caught in the Market or in its immediate vicinity; the remainder were more or less evenly distributed throughout the town. This fact is of remarkable significance and shows how severe the epizootic was in the neighbourhood of the Market and how comparatively mild it was in the rest of the town. During October, November and December 1324 rats were caught in the market and in three adjacent streets; of these rats 29 were plague infected, *i.e.* 2·2%. In the remainder of the town Shahapur and Sadar Bazaar during the same period 8528 rats were caught of which 55 were plague infected, *i.e.* 0·6%. Now the market and adjacent streets consist very largely of shops and godowns many of which are not used as dwelling houses at all. Of the 35 rats affected with acute plague caught in the Market, 22 were caught in grain godowns, stores, or grocers' shops (none of which were dwelling houses). In addition 10 rats presenting lesions of resolving or chronic plague were caught in these shops and godowns which lesions were proved to contain virulent plague bacilli. Over and above this number there were many more rats caught which presented lesions which we have good reasons to believe were the residue of an attack of acute plague (see article on resolving plague, p. 335 and maps).

The above figures can be taken as an indication that an epizootic of very considerable severity was raging in the neighbourhood of the Market at the height of the Belgaum epidemic. A reference has been made above to the weekly markets that are held in Belgaum at which not only the inhabitants of Belgaum itself but of all surrounding villages obtain their weekly stores. Given an epizootic such as we have seen raging in the Market it would be difficult to imagine more favourable conditions for the dissemination and spread of infection than this weekly gathering affords, a spread not only to other parts of Belgaum but to surrounding villages. The commission agents, such as those whose

stores, as we have seen above, were harbouring plague infected rats, import and export grain etc. by road and rail and sell it to retail and other wholesale dealers. The grain is contained in gunny bags which are capable of harbouring not only rat fleas but rats as well. It requires little imagination to picture what a serious danger a market such as that of Belgaum is, in times of plague, not only to itself but to all places with which it has trade intercourse. If there is one part of the town that is frequented by all the inhabitants, that part is the market. Godowns, in a market such as that of Belgaum, constructed as they are, and situated in the centre of the town, must always be a danger. The amount of food and shelter that they offer to rats is unlimited. There is always a danger of importation of plague infected rats or fleas or both in the sacks of grain and other stores that are continually being imported into these godowns and when once introduced with the large rat population that these buildings shelter there is nothing in the plague season to prevent the disease spreading and an epizootic and epidemic resulting.

V. Seasonal prevalence of plague in Belgaum.

We have already stated that our first object in Belgaum was to ascertain what factors existed every year in July, August and September especially favourable to plague, which brought about the constant appearance of plague epidemics at this season of the year. Our year's observations have shown that these are the very months in which the rat flea is most prevalent. Whereas in the off plague season the average number of fleas per *Mus rattus* is as low as four to five, in these months the count reaches the large figure of eighteen. Further we have shown that the early months of the year are those in which the breeding activity of *Mus rattus* is at a maximum.

The decline of the epidemics in the months of December and January is in the same way associated with a decline in flea prevalence. In this connection Chart I is of interest. It was constructed as follows: the average number of deaths from plague, taking into account all the epidemics that Belgaum has suffered from (twelve years in all), was worked out for each week of the year (see Table IV). The curve so constructed has been superimposed on the curve that illustrates the seasonal prevalence of the rat flea in Belgaum during the year 1908—09. The time correlation that exists between flea prevalence and plague deaths is illustrated in a striking manner.

An insufficient number of rats may however be of more importance in bringing about the decline of an epidemic. This was illustrated by the little epidemic in the Sadar Bazaar which came to an end at a time when fleas were very numerous. On the other hand an insufficient number of fleas would appear to be the more important of the two factors in explaining the absence of epidemic plague in the off season, when rats may be numerous.

The third question to which we endeavoured to find a solution related to the fate of plague in the off season. We had evidence of the existence of acute rat plague in the off season in a village only three miles from Belgaum where the climatic conditions were in every way comparable to those of Belgaum. We also observed apparently indigenous human plague cases in Belgaum City in the middle of the off season, when climatic conditions were least favourable. These facts demonstrate the possibility of the off season being bridged over by dropping cases of acute plague amongst the rats. The epidemic which we studied apparently owed its origin to importation of infection. It must be remembered that the off plague season in Belgaum is the plague season in Bombay City and other parts of the Presidency, with which Belgaum has trade intercourse. It would be difficult, therefore, and often impossible, to definitely exclude the possibility of importation of infection in the study of any given epidemic of plague in Belgaum.

Summary and general conclusions.

A study of all the epidemics of plague that have occurred in Belgaum from 1897 to 1909 shows that:

1. Plague cases can and do occur in any month of the year (see Table IV).

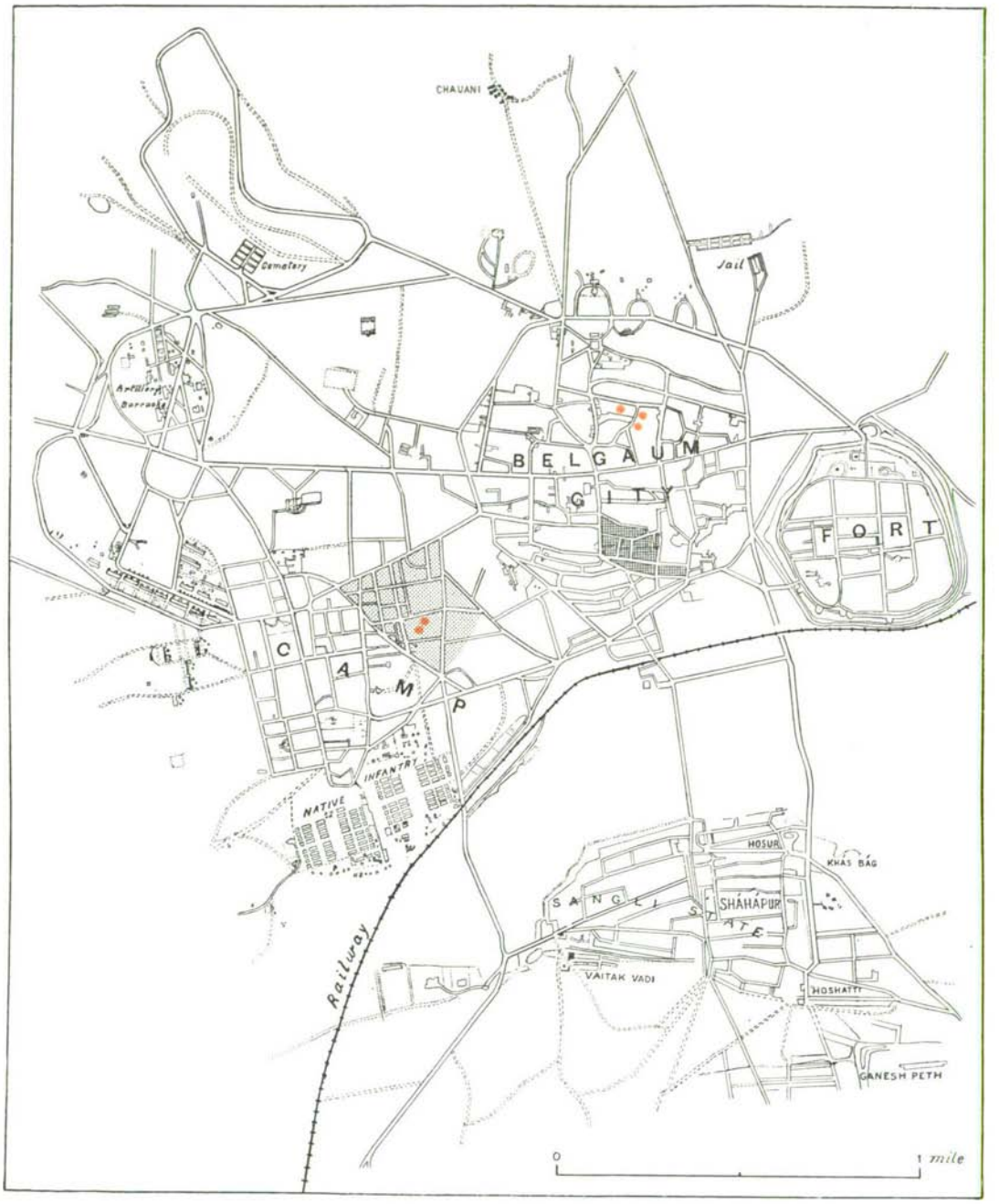
2. Though many of the cases that have occurred in the off plague seasons may have been imported, our observations have shown that indigenous cases (*i.e.* cases in which it was impossible to get a history of importation of infection) occur in the off plague season.

3. Though occasional cases may occur at any time of the year, plague can only assume epidemic proportions in the latter half of the year, July to November.

4. This seasonal prevalence is remarkably constant.

5. There has been a tendency for the epidemics to become progressively milder.

MAP II



BELGAUM CITY AND ENVIRONS

Pre-epidemic period—May and June, 1908

● Human Plague Case

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MAP III

BELGAUM CITY AND ENVIRONS

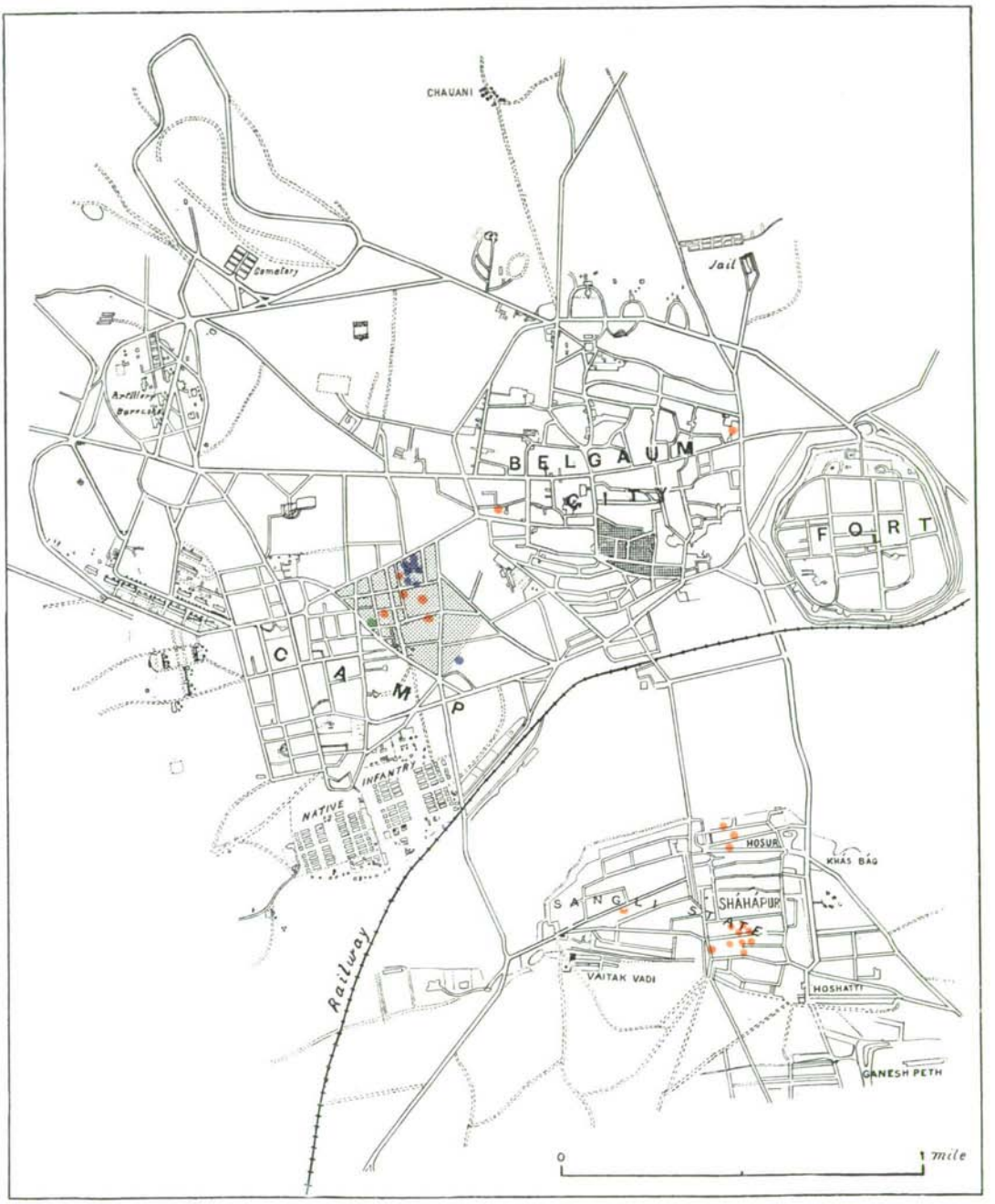
July, 1908

● Human Plague Case

● Plague infected Rat (acute)

https://doi.org/10.1017/S0022172400043060 Published online by Cambridge University Press

MAP IV



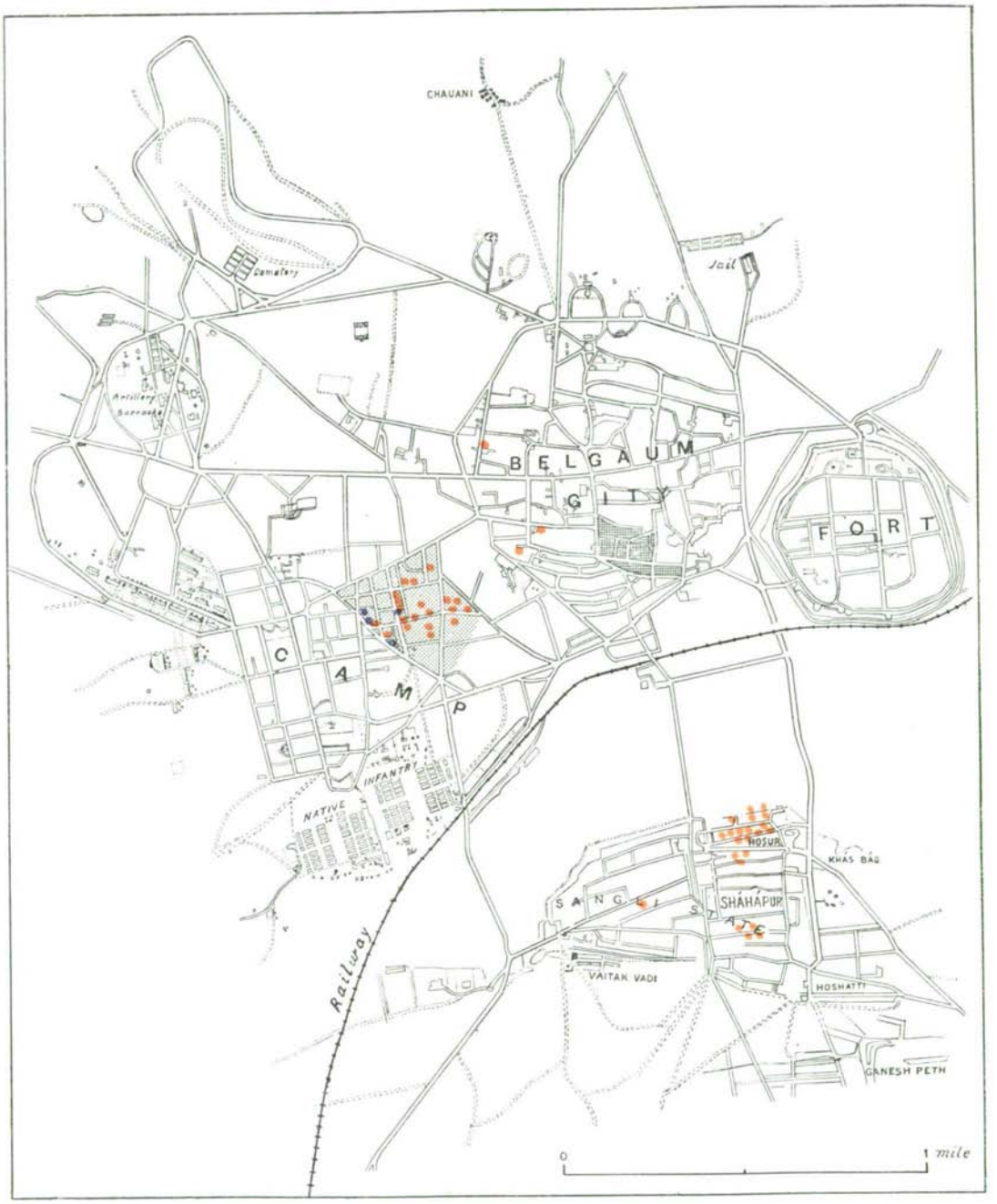
BELGAUM CITY AND ENVIRONS

August 1st—15th, 1908

- Human Plague Case
- Plague infected Rat (acute)
- Resolving Plague Rat

https://doi.org/10.1017/S0022172400043060 Published online by Cambridge University Press

MAP V



BELGAUM CITY AND ENVIRONS

August 16th—31st, 1908

● Human Plague Case

● Plague infected Rat (acute)

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MAP VI

BELGAUM CITY AND ENVIRONS

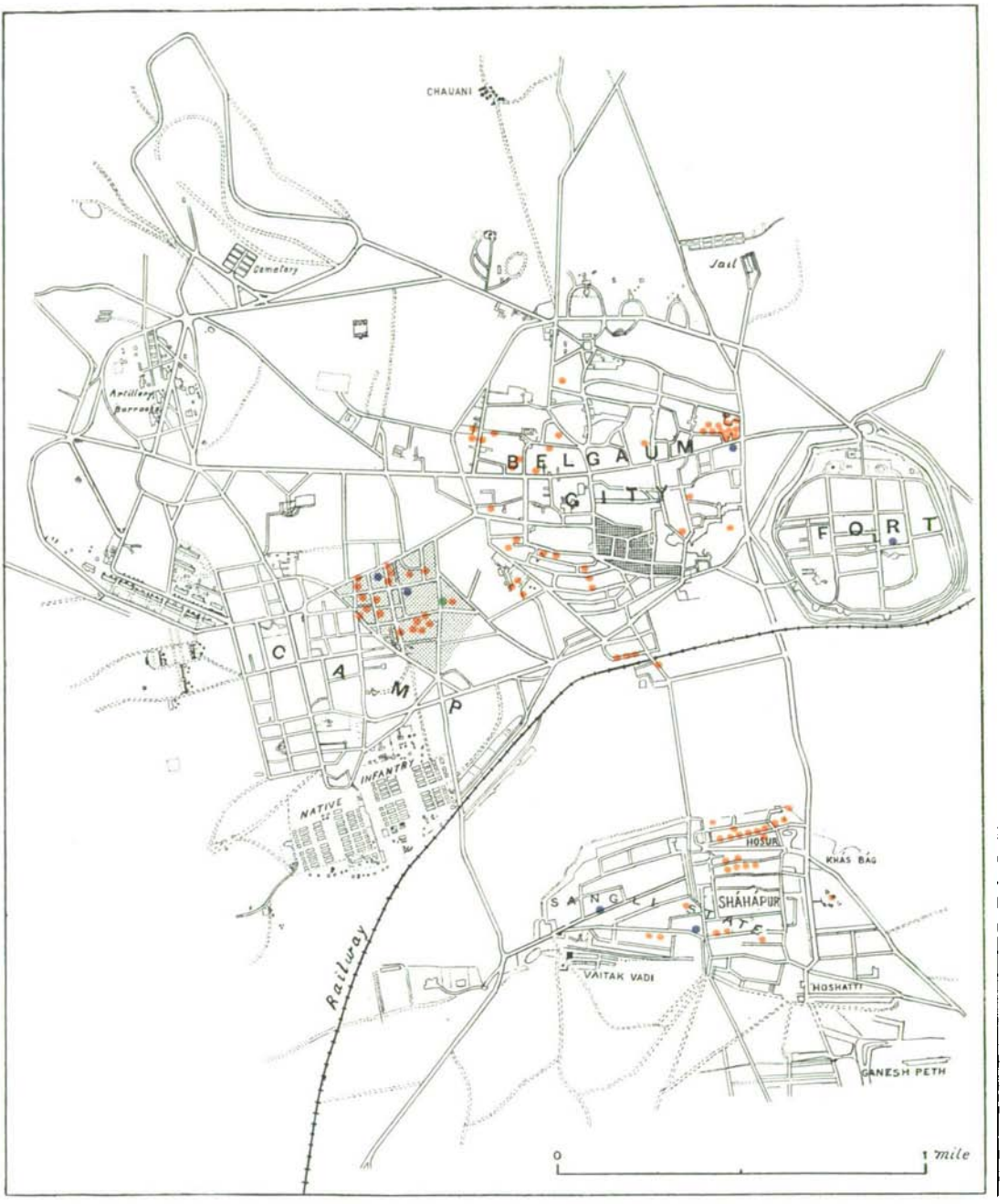
September 1st—15th, 1908

● Human Plague Case

● Plague infected Rat (acute)

https://doi.org/10.1017/S0022172400043060 Published online by Cambridge University Press

MAP VII



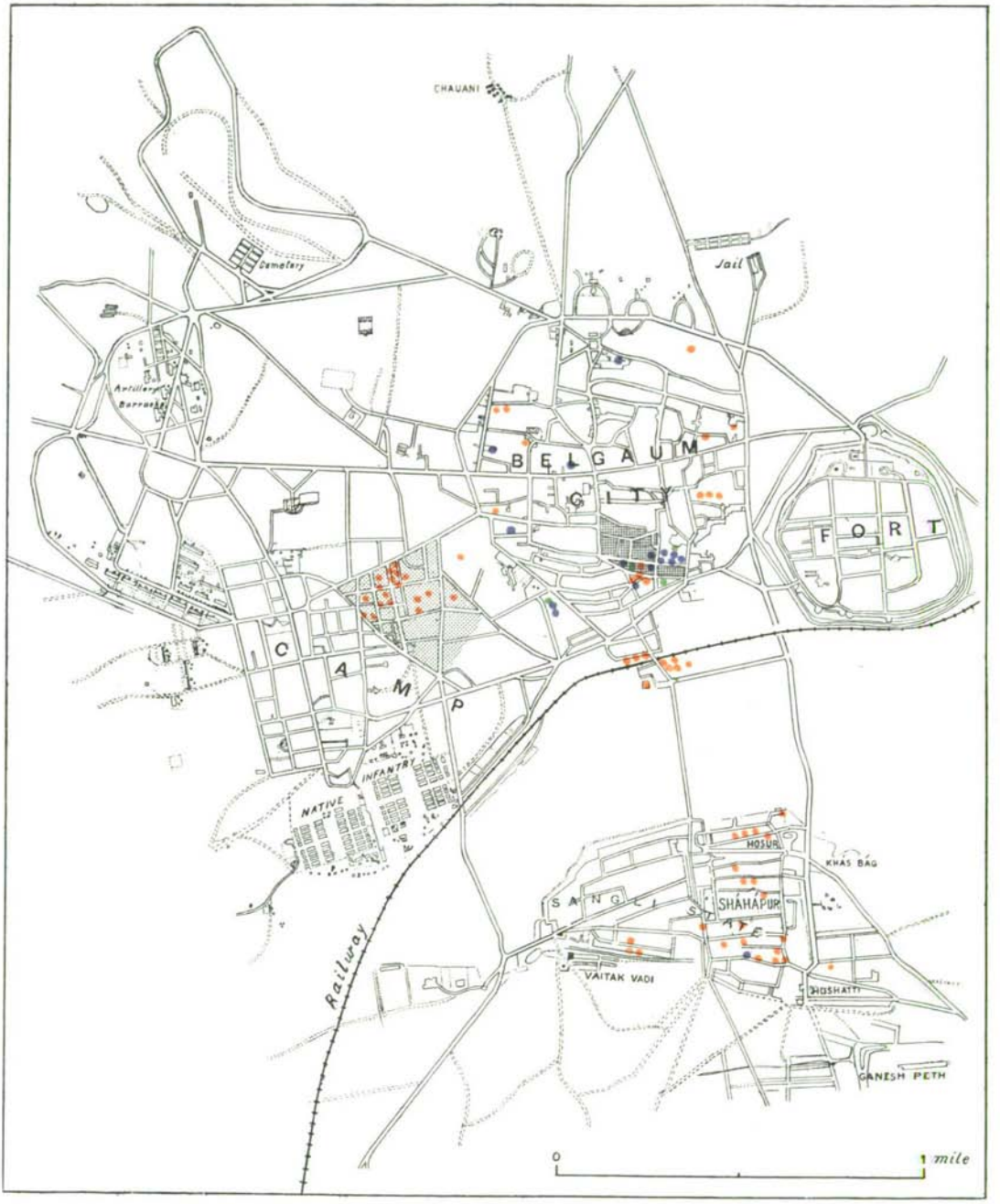
BELGAUM CITY AND ENVIRONS

September 16th—30th, 1908

- Human Plague Case
- Plague infected Rat (acute)
- Resolving Plague Rat

https://doi.org/10.1017/S0022172400043060 Published online by Cambridge University Press

MAP VIII



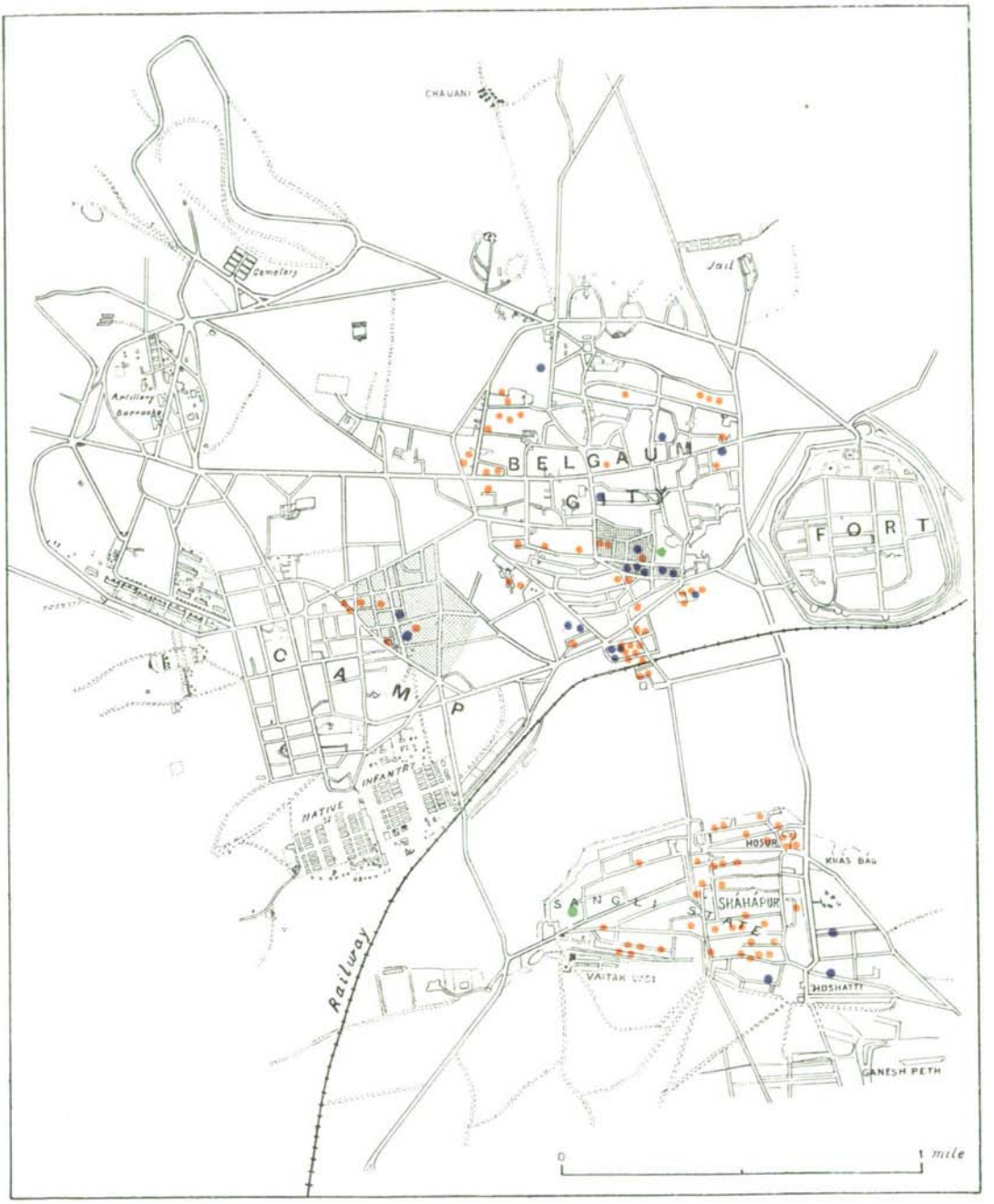
BELGAUM CITY AND ENVIRONS

October 1st—15th, 1908

- Human Plague Case
- Plague infected Rat (acute)
- Resolving Plague Rat

https://doi.org/10.1017/S0022172400043060 Published online by Cambridge University Press

MAP IX



BELGAUM CITY AND ENVIRONS

October 16th—31st, 1908

- Human Plague Case
- Plague infected Rat (acute)
- Resolving Plague Rat

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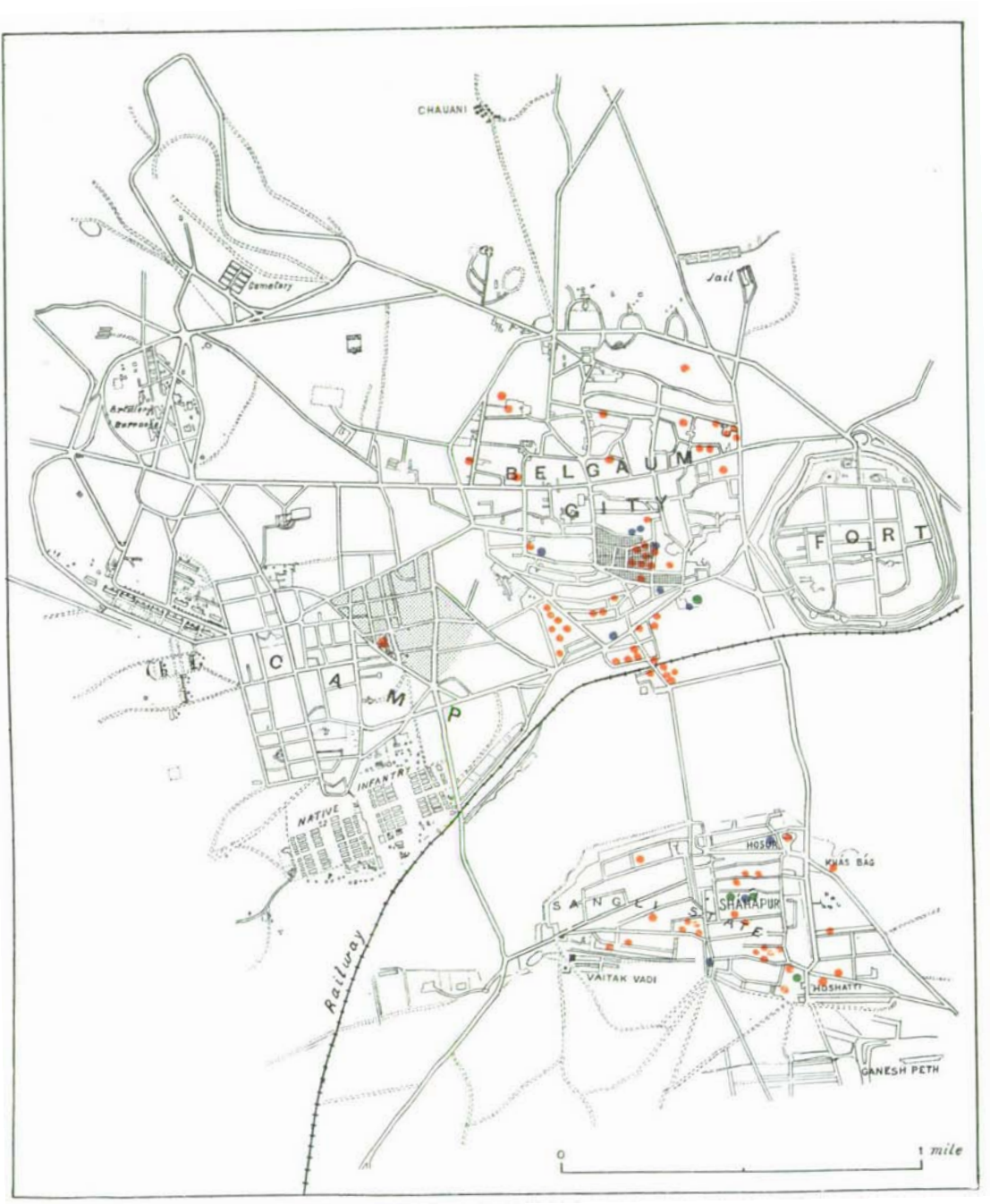
MAP X



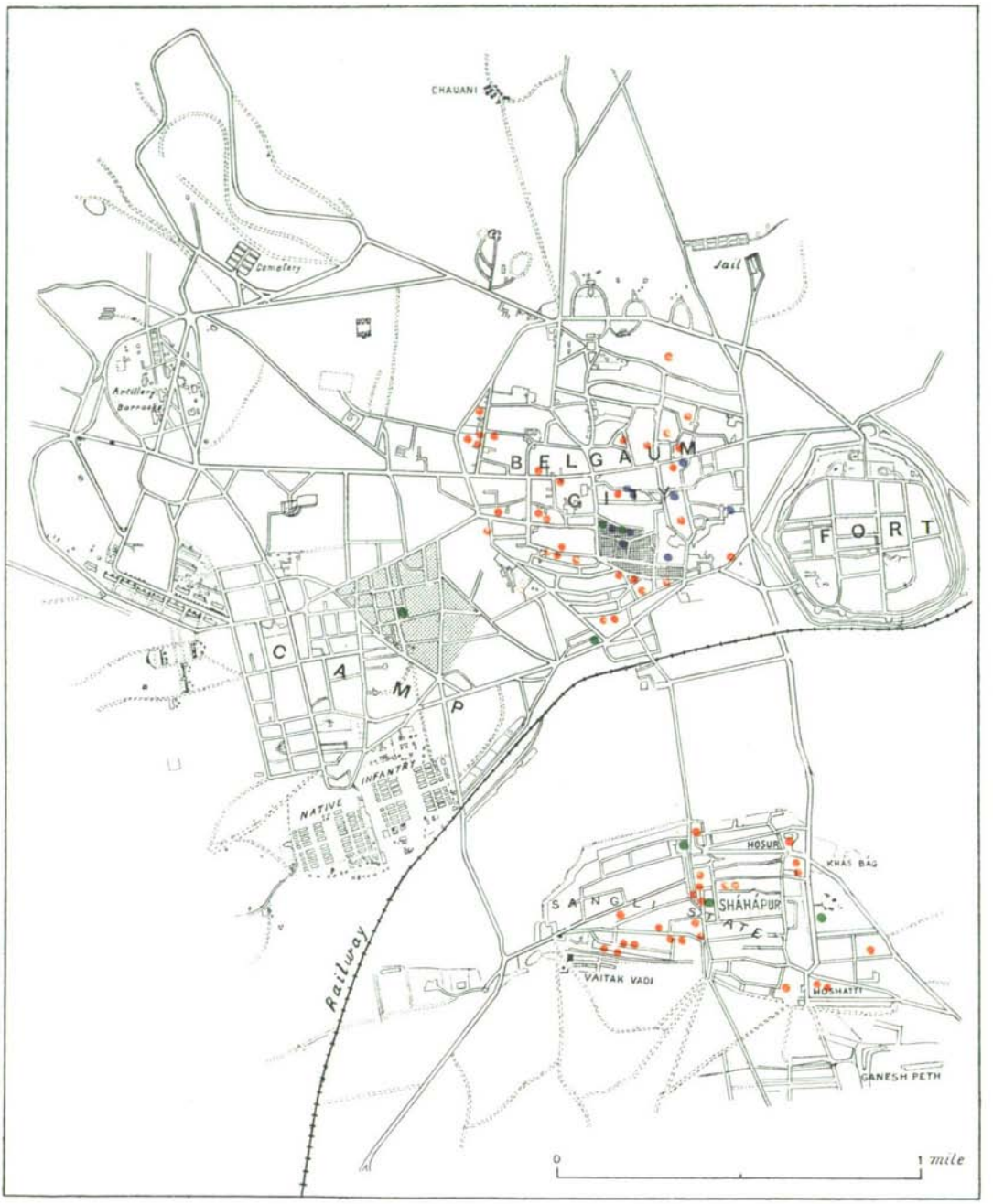
BELGAUM CITY AND ENVIRONS

November 1st—15th, 1908

- Human Plague Case
- Plague infected Rat (acute)
- Resolving Plague Rat

https://doi.org/10.1017/S0022172400043060 Published online by Cambridge University Press

MAP XI



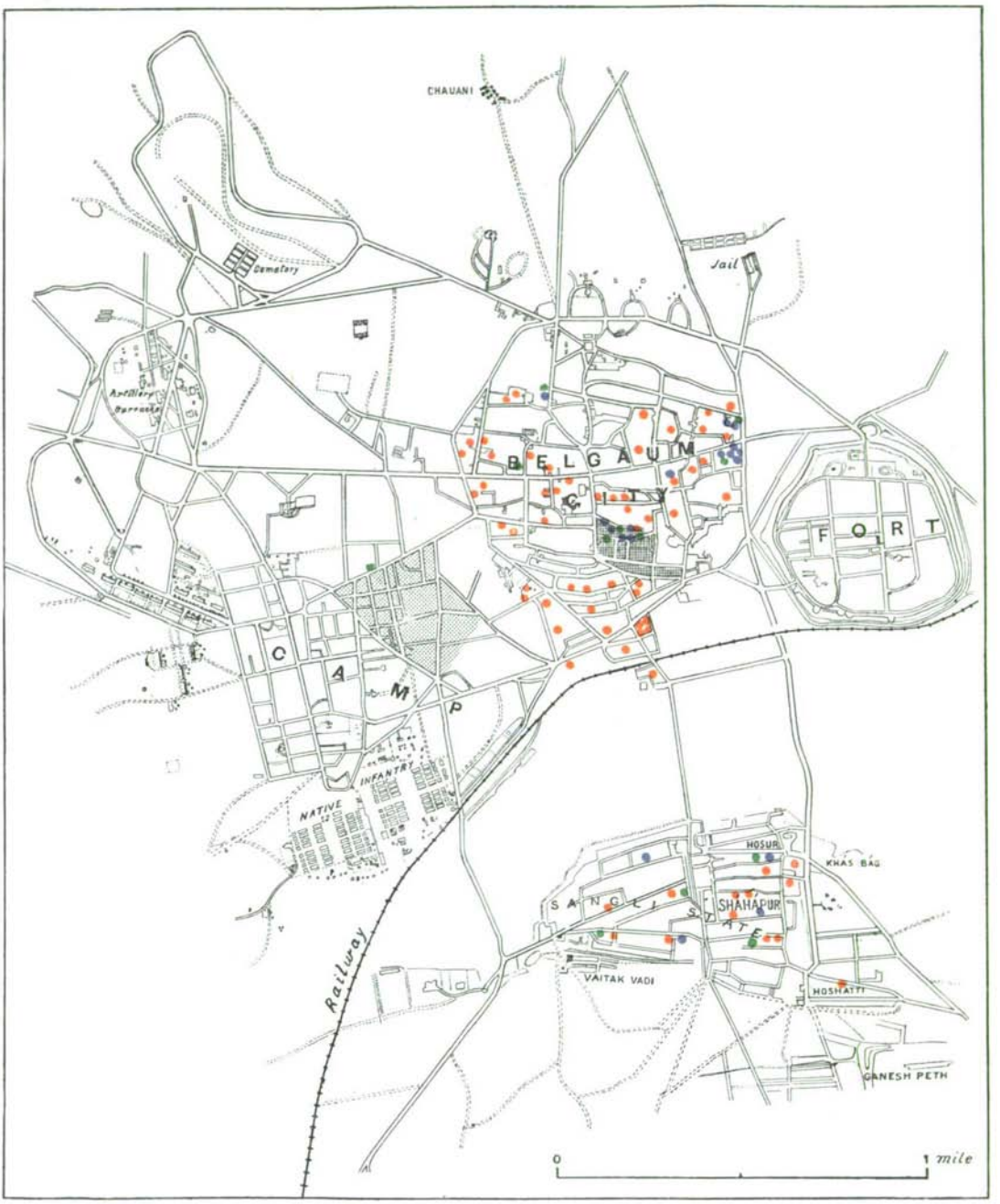
BELGAUM CITY AND ENVIRONS

November 16th—30th, 1908

- Human Plague Case
- Plague infected Rat (acute)
- Resolving Plague Rat

https://doi.org/10.1017/S0022172400043060 Published online by Cambridge University Press

MAP XII



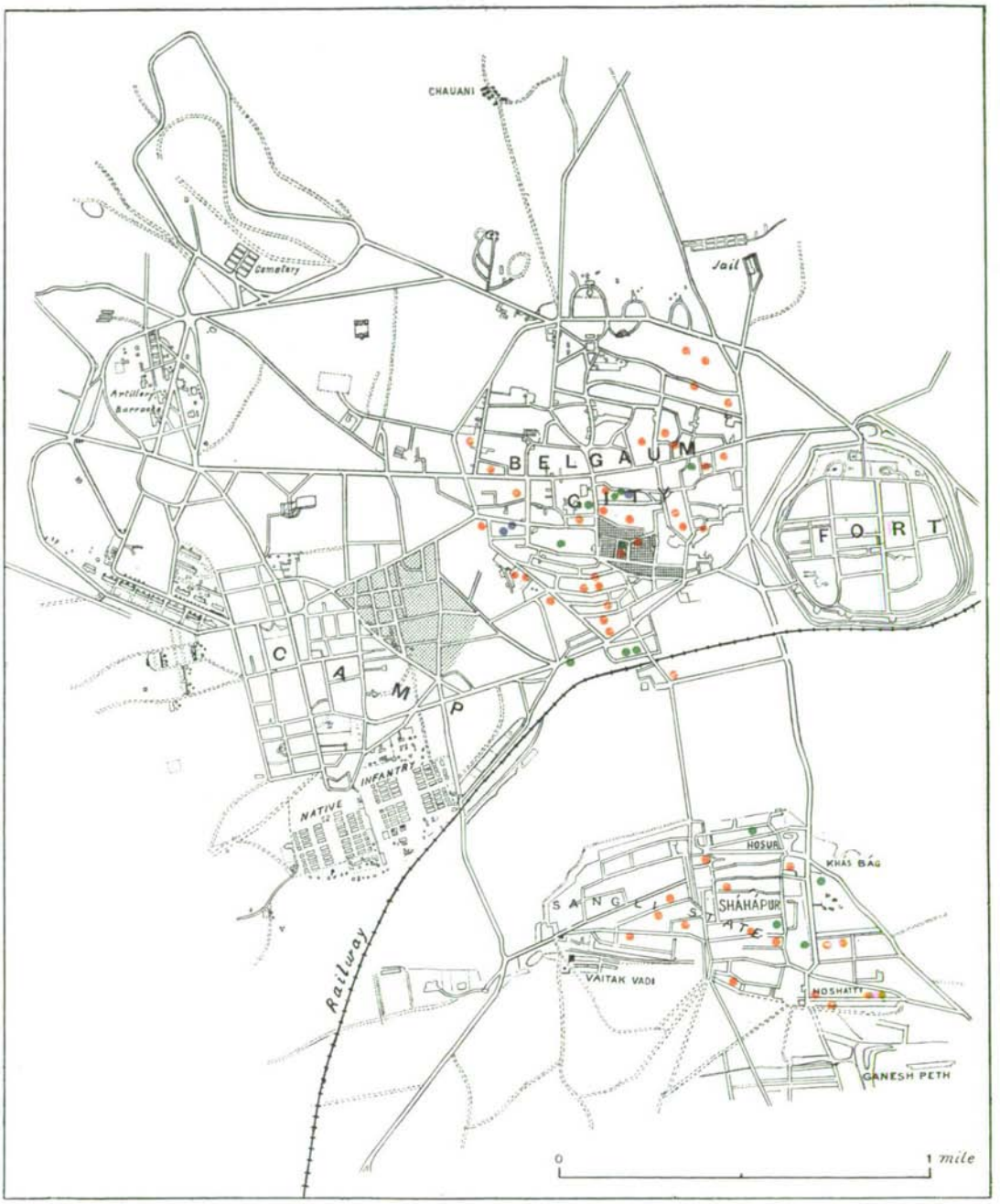
BELGAUM CITY AND ENVIRONS

December 1st—15th, 1908

- Human Plague Case
- Plague infected Rat (acute)
- Resolving Plague Rat

https://doi.org/10.1017/S0022172400043060 Published online by Cambridge University Press

MAP XIII



BELGAUM CITY AND ENVIRONS

December 16th—31st, 1908

- Human Plague Case
- Plague infected Rat (acute)
- Resolving Plague Rat

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MAP XIV

BELGAUM CITY AND ENVIRONS

January, 1909

- Human Plague Case
- Plague infected Rat (acute)
- Resolving Plague Rat

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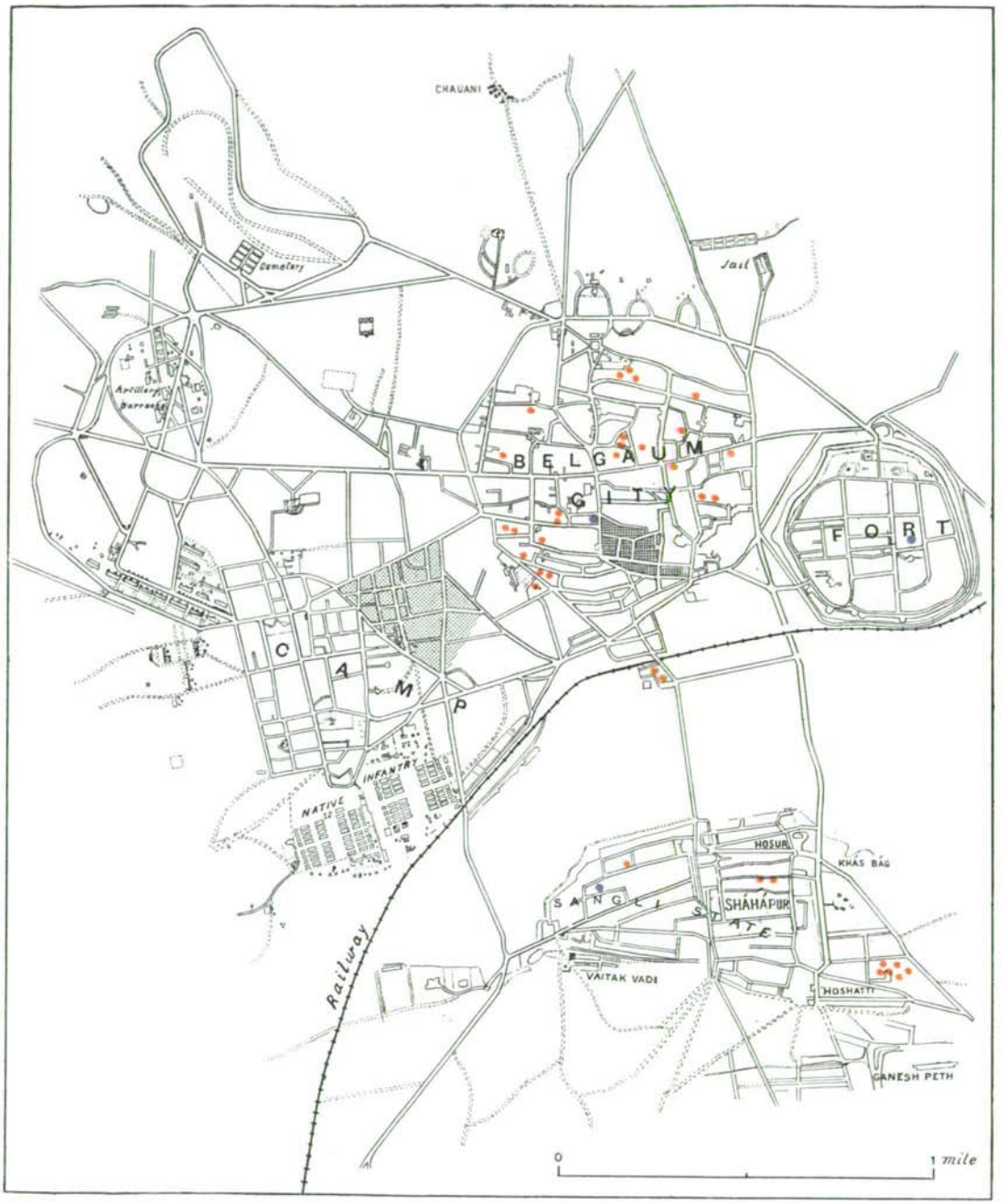
MAP XV



BELGAUM CITY AND ENVIRONS

February, 1909

● Human Plague Case

● Plague infected Rat (acute)

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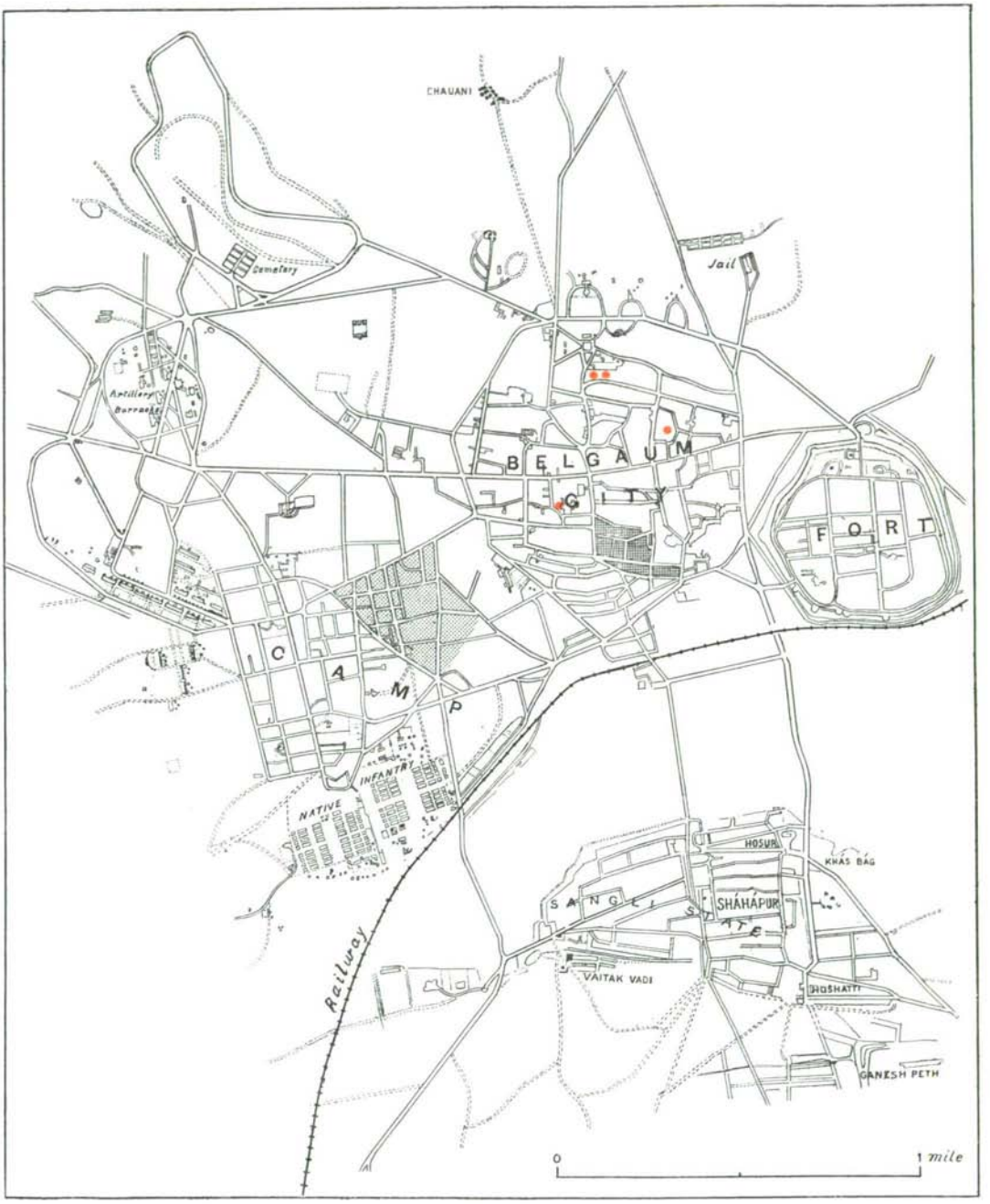
MAP XVI



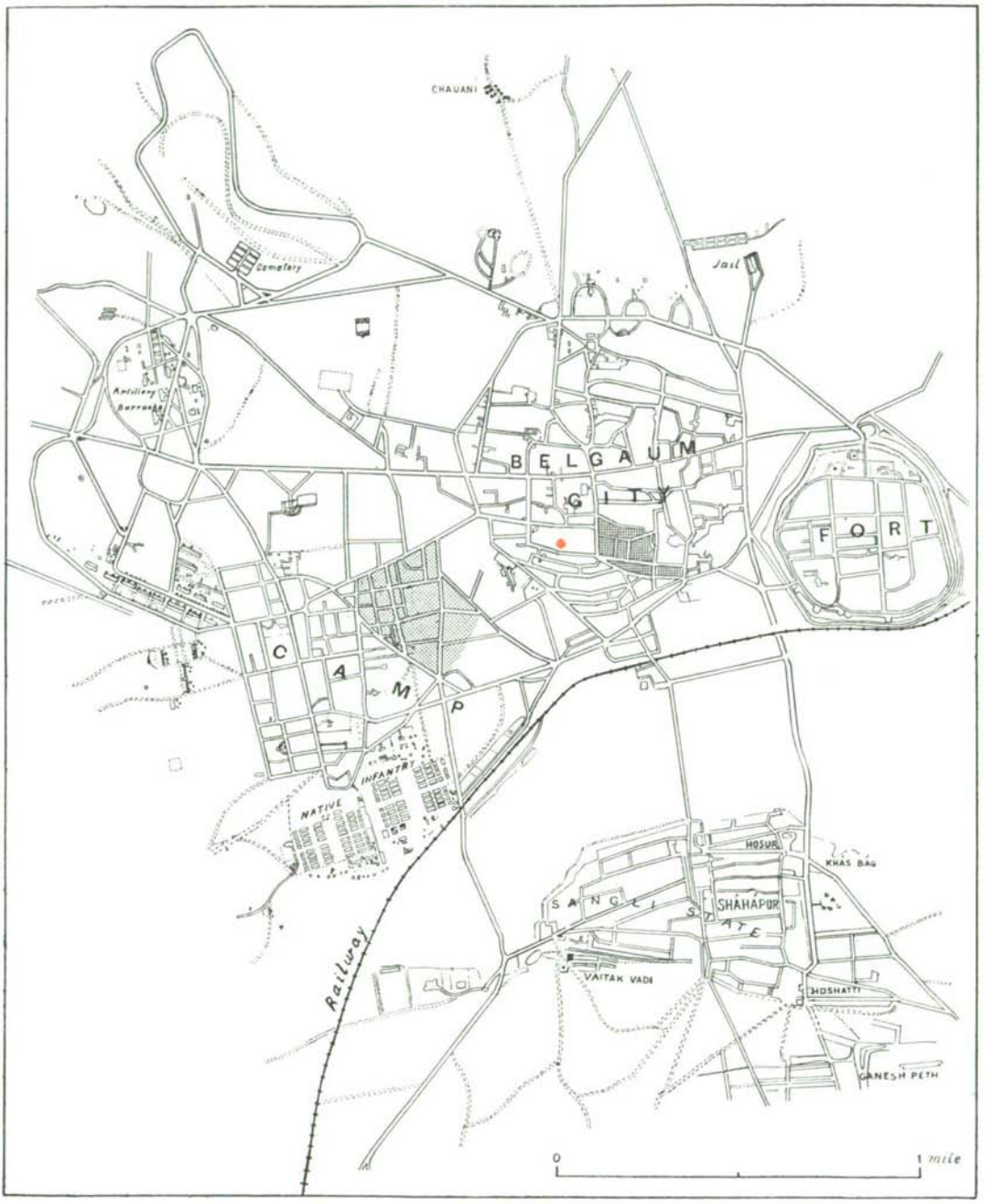
BELGAUM CITY AND ENVIRONS

March, 1909

● Human Plague Case

https://doi.org/10.1017/S0022172400043060 Published online by Cambridge University Press

MAP XVII



BELGAUM CITY AND ENVIRONS

April, 1909

● Human Plague Case

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Our observations carried out in Belgaum in 1908—09 indicate :—

(A) That there is in Belgaum a definite seasonal variation in the prevalence of the rat flea, *Loemopsylla cheopis*.

(B) That this seasonal prevalence of the rat flea is closely correlated with the seasonal prevalence of plague.

(C) If it be granted that the seasonal prevalence of fleas is likely to be constant year after year, the height of each epidemic that has ever occurred in Belgaum was in a month of the year in which the rat flea was very prevalent.

(D) That there appears to be a close connection between the flea population and the hygrometric condition of the atmosphere. It would appear probable that the relation between the two is particularly close within certain limits of temperature.

(E) That the onset of an epidemic, if infection be present, follows and is determined by a rise in the number of rat fleas.

TABLE I.

Summary of Mus rattus caught and examined in Belgaum. May 1908—*June* 1909.

Week ending	Total no. of rats examined	No. of rats on which fleas were counted	Total no. of fleas	Average no. of fleas per rat	Total no. of adult females	Total no. of pregnant females	Percentage of adult females pregnant	Average no. of foetuses	Total no. of young rats (70 gms. and under)	Percentage young of total	No. of rats per 100 traps set
May 16 '08	211	211	721	3·4	78	30	38·4	6·0	70	33·1	30·5
23	412	412	1975	4·7	155	91	58·7	5·1	137	33·2	29·1
30	829	829	3931	4·7	280	174	62·1	5·6	330	39·8	35·4
June 6	887	788	4606	5·8	300	167	55·6	5·6	341	38·4	36·6
13	636	621	4653	7·4	192	104	54·1	5·2	220	34·4	26·1
20	718	718	4955	6·9	253	135	53·3	5·3	254	35·3	28·9
27	834	834	7839	9·4	277	128	46·2	5·2	325	38·9	33·3
July 4	771	656	7120	10·9	265	98	37·0	5·3	283	36·7	31·2
11	1037	1035	12794	12·4	327	182	55·6	5·7	355	34·2	35·4
18	1006	706	12003	17·0	360	178	49·4	5·9	336	33·4	34·6
25	890	756	13940	18·4	310	182	58·7	5·7	324	36·4	33·1
Aug. 1	984	902	15745	17·5	317	130	41·0	5·6	371	37·7	35·6
8	905	762	13235	17·4	340	151	44·4	6·0	302	33·3	29·3
15	835	804	11968	14·9	319	95	29·7	5·3	303	36·2	28·2
22	933	886	13987	15·8	345	92	26·6	5·5	275	29·5	30·7
29	811	795	12534	15·8	259	93	35·9	6·0	275	33·9	27·4
Sept. 5	655	630	10127	16·0	226	80	35·4	5·7	253	38·6	24·0
12	957	924	17030	18·4	305	88	28·8	5·1	358	37·4	32·6
19	954	888	15514	17·4	303	81	26·7	5·5	374	39·2	33·1
26	865	841	12751	15·2	253	36	14·2	5·2	291	33·6	29·9
Oct. 3	774	741	13816	18·6	265	67	25·3	5·3	259	33·5	26·8
10	759	736	12243	16·6	211	61	28·9	5·4	326	42·9	26·0
17	816	782	11725	15·0	252	86	34·1	5·4	311	38·1	28·1
24	916	896	11651	13·0	327	100	30·6	5·3	326	35·4	31·3
31	838	820	10854	13·2	289	58	20·0	5·1	294	35·0	28·3
Nov. 7	699	696	9913	14·2	215	44	20·5	5·0	274	39·2	24·4
14	777	764	11449	15·0	239	46	19·2	5·0	307	39·5	26·5
21	692	674	9756	14·5	197	66	33·5	5·0	261	38·7	23·8
28	750	741	7860	10·6	250	67	26·8	4·8	243	32·4	25·8
Dec. 5	724	698	7077	10·1	232	72	31·0	5·3	221	30·5	25·3
12	602	592	4914	8·3	164	48	29·3	5·4	244	40·5	21·5
19	582	568	4953	8·7	175	39	22·25	5·2	183	31·4	20·4
26	592	573	3127	5·4	196	56	28·5	5·3	188	30·7	24·0
Jan. 2 '09	461	449	2850	6·3	155	56	36·1	5·0	139	30·1	18·5
9	343	337	1889	5·6	114	31	27·2	5·3	99	29·0	14·1
16	461	404	2379	5·8	158	33	20·9	5·3	141	30·6	16·6
23	423	404	1978	4·9	149	72	48·3	5·0	118	27·9	14·2
30	451	442	2968	6·7	144	76	52·8	5·6	163	36·0	15·2
Feb. 6	392	372	2749	7·4	120	56	46·6	5·1	145	37·0	13·2
13	422	412	3724	9·0	122	76	62·3	5·3	183	43·3	14·2
20	420	417	3247	7·7	101	72	71·2	5·4	203	48·3	17·1
27	498	490	3378	6·9	121	65	53·7	5·7	223	44·7	16·6
Mar. 6	422	412	2723	6·6	105	54	51·4	5·2	208	49·3	15·2
13	370	356	1872	5·25	89	49	55·0	5·1	202	54·6	13·6
20	462	460	2114	4·6	132	63	47·7	5·5	193	41·7	16·6
27	439	436	3048	7·0	109	54	50·0	5·8	227	51·7	15·6
April 3	483	474	2759	5·8	123	59	48·0	5·4	222	46·0	15·2
10	480	474	2806	5·9	126	59	46·8	5·1	255	53·1	14·0
17	486	477	2738	5·7	120	59	49·1	5·4	234	48·1	13·9
24	633	627	3144	5·0	162	79	48·8	5·9	306	48·3	17·7
May 1	585	575	2373	4·1	119	41	34·4	5·5	314	53·6	16·0
8	559	543	2049	3·7	124	65	52·4	5·2	301	53·8	15·0
15	554	539	1945	3·6	154	57	37·0	5·5	246	44·4	15·2
22	535	533	2131	4·0	123	80	65·0	5·2	257	48·0	14·7
29	561	547	2151	3·9	150	65	43·3	4·6	293	52·2	15·4
June 5	591	580	3230	5·5	154	111	72·0	5·0	282	47·0	16·4
12	591	579	3163	5·4	147	82	55·7	5·0	287	48·5	16·6
19	640	619	4626	7·4	160	119	74·3	5·2	290	45·3	18·0
26	671	653	5878	9·0	167	83	49·7	4·8	346	51·5	22·0

TABLE II.

Belgaum. 1908—1909.

Week ending	Mean temperature	Humidity	Wet bulb reading
May 23 '08	78·8	68·8	72·5
30	79·0	67·5	72·0
June 6	79·0	68·8	72·5
13	77·5	75·8	72·5
20	73·0	86·3	70·5
27	74·5	81·3	71·0
July 4	71·8	90·1	70·0
11	71·2	91·4	69·5
18	70·5	92·7	69·25
25	71·0	90·5	69·3
Aug. 1	71·0	93·6	70·0
8	71·1	93·0	70·0
15	70·8	89·4	69·0
22	71·1	89·4	69·0
29	70·8	89·5	69·0
Sept. 5	72·5	83·6	69·5
12	72·0	79·2	68·0
19	72·5	83·6	69·5
26	73·2	84·8	70·0
Oct. 3	74·0	76·3	69·5
10	74·6	69·4	68·5
17	75·2	69·7	69·25
24	74·5	71·0	68·5
31	75·0	77·0	70·5
Nov. 7	73·7	69·5	67·0
14	68·9	66·1	62·5
21	66·0	53·8	56·6
28	67·7	63·3	60·7
Dec. 5	66·9	51·7	57·0
12	66·3	58·3	57·7
19	65·2	58·8	57·0
26	66·8	66·6	62·5
Jan. 2 '09	68·3	65·6	61·5
9	71·5	69·1	65·5
16	68·4	66·7	62·0
23	70·0	64·0	62·7
30	71·9	59·8	63·7
Feb. 6	68·6	56·0	59·5
13	72·5	59·3	64·7
20	72·9	62·1	65·0
27	79·3	59·8	70·5
Mar. 6	78·4	49·5	66·5
13	78·5	56·3	68·5
20	79·4	56·4	69·5
27	79·3	59·8	70·5
April 3	79·2	57·0	69·3
10	79·2	53·5	68·0
17	79·7	53·7	68·7
24	78·3	63·0	70·0
May 1	82·2	60·2	73·0
8	80·5	67·7	73·5
15	78·3	70·5	72·0
22	81·2	65·5	73·5
29	80·5	66·2	73·5
June 5	75·0	74·0	70·0
12	72·5	88·0	70·5
19	73·0	81·5	69·5
26	73·0	83·0	70·0

The "mean" temperature in this table was calculated from the daily maximum and minimum readings. It is therefore not accurately speaking a true mean temperature. It has been found however in the case of Belgaum that the result so obtained does not differ from the true mean temperature calculated from hourly readings (as well as by the use of Herschel's formula) by more than two-thirds to one degree. The humidity was worked out in a similar way.

TABLE III.

Plague cases and deaths in Belgaum during 1908—1909.

Week ending	City*		(Sadar Bazaar)† Cantonment		Shahapur		Total	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
June 6 '08	1	1	2	0	0	0	3	1
13	2	2	0	0	0	0	2	2
20	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0
July 4	0	0	0	0	0	0	0	0
11	0	0	1	0	0	0	1	0
18	3	3	0	1	0	0	3	4
25	4	3	0	0	0	0	4	3
Aug. 1	2	0	0	0	0	0	2	0
8	3	2	2	1	5	4	10	7
15	2	0	3	2	5	5	10	7
22	5	3	8	6	2	1	15	10
29	10	7	11	11	5	1	26	19
Sept. 5	14	12	11	8	5	4	30	24
12	20	14	17	13	2	2	39	29
19	26	16	16	9	3	0	45	25
26	23	13	10	10	1	1	34	24
Oct. 3	26	16	11	7	8	2	45	25
10	18	12	7	5	4	4	29	21
17	8	6	7	3	8	4	23	13
24	20	16	4	2	21	7	45	25
31	33	21	1	1	13	11	47	33
Nov. 7	27	21	1	0	9	7	37	28
14	43	23	1	1	9	8	53	32
21	23	14	0	0	9	5	32	19
28	15	9	0	0	5	4	20	13
Dec. 5	32	19	0	0	10	6	42	25
12	20	12	1	0	3	1	24	13
19	23	17	0	0	5	5	28	22
26	16	11	0	0	5	5	21	16
Jan. 2 '09	13	10	0	0	4	3	17	13
9	11	10	0	0	6	5	17	15
16	11	6	0	0	1	1	12	7
23	7	5	0	0	5	1	12	6
30	4	3	0	0	3	3	7	6
Feb. 6	14	7	0	0	2	1	16	8
13	8	5	0	0	1	2	9	7
20	8	6	0	0	0	0	8	6
27	5	2	0	0	2	1	7	3
Mar. 6	3	0	0	0	0	1	3	1
13	1	1	0	0	1	0	2	1
20	2	2	0	0	0	0	2	2
April 17	1	1	0	0	0	0	1	1
Total	507	331	114	80	162	105	783	516

* Municipal area including suburbs.

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TABLE IV.

Plague deaths in Belgaum—week by week—for the years 1897—1909.

Week ending	1897	98	99	1900	01	02	03	04	05	06	07	08	09	Totals
Jan. 2	—	49	8	0	1	6	3	9	9	0	0	10	10	105
9	—	63	7	1	0	2	6	10	6	4	0	7	10	116
16	—	59	7	4	0	1	6	8	3	7	0	4	6	105
23	—	48	2	5	0	3	7	7	6	4	0	7	5	94
30	—	39	4	2	0	4	10	5	5	4	0	3	3	79
Feb. 6	—	23	4	2	0	3	8	12	6	4	0	6	7	75
13	—	12	8	2	0	0	3	1	7	6	0	4	5	48
20	—	6	6	2	1	1	3	2	1	9	0	8	6	45
27	—	12	3	3	1	0	5	2	3	4	0	7	2	42
Mar. 6	—	10	7	2	1	1	4	2	6	5	0	13	0	51
13	—	7	2	3	0	0	5	3	2	4	0	3	1	30
20	—	0	1	0	1	1	1	2	1	8	0	1	2	18
27	—	7	6	4	1	0	0	3	1	3	0	1	0	26
April 3	—	5	2	4	1	1	1	0	1	1	0	1	0	17
10	—	0	1	2	0	0	4	0	0	1	0	3	0	11
17	—	1	4	2	0	1	1	1	0	2	0	0	1	13
24	—	2	8	6	0	0	4	0	0	0	0	0	0	20
May 1	—	1	9	8	0	0	0	0	0	0	0	0	0	18
8	—	2	11	2	1	0	0	2	0	0	0	0	0	18
15	—	2	14	1	5	0	2	0	0	0	0	0	0	24
23	0	2	34	1	0	1	0	1	0	0	0	0	—	39
30	0	0	41	7	0	0	0	1	1	2	0	0	—	52
June 6	0	0	43	6	0	1	0	0	0	1	0	1	—	52
13	0	1	42	2	0	0	2	0	0	0	0	2	—	49
20	0	8	54	4	1	0	1	0	0	0	0	0	—	68
27	0	3	59	2	0	1	4	0	1	0	0	0	—	70
July 4	0	12	97	3	0	2	2	1	1	0	0	0	—	118
11	0	11	117	7	0	0	9	0	0	1	0	0	—	145
18	0	52	160	5	3	4	7	2	3	0	0	4	—	240
25	0	74	183	8	3	0	5	4	2	0	0	3	—	282
Aug. 1	0	80	214	22	7	0	5	2	0	0	0	0	—	330
8	0	61	226	20	5	2	2	6	5	0	0	3	—	330
15	0	64	193	16	16	5	9	6	7	0	0	2	—	318
22	0	68	134	57	23	16	19	6	2	0	0	9	—	334
29	0	68	118	97	29	20	21	12	8	0	0	18	—	391
Sept. 5	0	82	110	130	40	27	42	17	11	0	0	20	—	479
12	0	136	81	157	51	35	43	32	13	0	0	27	—	575
19	0	147	35	175	67	70	65	32	12	1	0	25	—	629
26	0	180	23	184	90	114	81	44	15	1	2	23	—	757
Oct. 3	0	255	6	177	87	118	90	65	15	1	1	23	—	838
10	0	261	6	129	95	128	99	58	17	1	0	17	—	811
17	0	274	9	131	89	164	88	61	16	0	3	9	—	844
24	0	238	3	86	77	149	84	47	21	0	4	18	—	727
31	5	148	5	38	86	136	83	98	11	0	2	22	—	634
Nov. 7	20	91	4	16	75	88	62	69	20	1	7	21	—	474
14	14	90	0	8	44	88	44	51	21	0	9	24	—	393
21	21	60	6	4	52	63	63	41	14	0	14	14	—	352
28	38	47	5	10	25	55	27	33	14	0	14	9	—	277
Dec. 5	61	19	4	5	21	43	23	34	21	0	6	19	—	256
12	39	24	3	5	15	31	20	26	16	0	4	12	—	195
19	36	15	1	3	5	18	12	21	9	0	11	17	—	148
26	52	13	0	1	5	17	10	7	13	0	9	11	—	138
Total	286	2932	2130	1571	1024	1420	1095	846	346	75	86	431	58	12300

Appendix.

A census of men and animals in Belgaum.

Towards the close of our observations in Belgaum, a census was made of the City and the Sadar Bazaar Camp.

A few notes were made of the structure of each house, the number of inmates, and the caste, occupation and trade of the inhabitants. In addition notes were made of the number of animals, buffaloes, bullocks, cows, ponies, goats, dogs, cats, chickens that shared with their owners the shelter of their abodes. Further information as to the number of rats that had been caught in each house was filled in from our laboratory records. A note was also made against each house as to the number of plague cases and deaths that had occurred therein during the epidemic that we had had under observation.

We hoped that we might be able to learn something from the mass of facts so collected about the influence that the various habits and mode of living of the people had on the degree of infestation of their houses with rats. No facts of any great practical value or importance have come to light, nor have the results been at all commensurate with the great labour involved.

In Belgaum City (excluding suburbs) there are 4927 houses; of this number 3813 are inhabited, *i.e.* dwelling houses; 1114 are uninhabited, *i.e.* they are shops, godowns or stores, or else are dwelling houses that were empty or locked at the time of our visit. The human population was 23,885, which gives an average of 6·2 persons per inhabited house.

In the Sadar Bazaar there are 642 inhabited houses, and 151 uninhabited. The population is 3507, an average of 5·4 persons per house.

The houses in Belgaum are all numbered; it occasionally happened however that more than one house bore the same number; this fact as well as other errors in numbering rendered it occasionally impossible for us to subsequently identify houses in which we had previously caught rats: this did not occur sufficiently often however as to in any way vitiate our general results.

During the fourteen months that our observations lasted in Belgaum City only 20,684 rats were caught in 2422 houses, an average of 8·5 rats per house. In this calculation we have excluded all houses in which we failed to catch one or more rats. The cause of our failure to catch any

rats after repeated trial in any given house was in the vast majority of cases attributable to the unwillingness of the inmates to help us. They either placed the traps in places inaccessible to rats, or else liberated the rats that had been caught. We assume that efficient trapping will succeed in catching at least one rat a year in every house in Belgaum. During the twelve months observations in the Sadar Bazaar 3077 rats were caught in 370 houses, an average of 8·3 rats per house.

Of the inhabited houses in the city we found that 1128 harboured either buffaloes, bullocks, cows, ponies or goats. The number of such animals was 3208, an average of nearly three per house. These figures will give some idea of the close association with domestic animals in which the Indian lives. In 623 houses that harboured one or more such animals, 5738 rats were caught, an average of 9·2 rats per house. In 1799 houses that contained no such animals 14,946 rats were caught, an average of 8·3 rats per house. In the Sadar Bazaar Camp, 402 rats were caught in 42 houses that harboured some of these larger domestic animals, in addition to their human inmates—an average of nearly ten rats per house; whereas in 328 houses that contained no such animals, 2675 rats were caught, an average of eight rats per house. Thus it would appear that the common custom of keeping such domestic animals in dwelling houses favours rat infestation but not to any very marked degree. The extra food supply available for rats in such houses does not appear to have the marked influence that one would anticipate.

There was only one house in Belgaum in which more than one hundred rats were caught in the course of the year; this was a grocer's shop in the City Market. It was a small house of three rooms, occupied by six people, Mahomedans. In this one house alone one hundred and ninety-seven rats were caught. It is a curious fact that this house possessed two cats. There were seventeen houses in which more than fifty and less than a hundred rats were caught; nine of these were ordinary dwelling houses, two were grocers' shops, one a grain godown, two liquor shops, one butcher shop, one stable, and one weaver's house. Two hundred and thirty-seven houses yielded a catch of more than twenty but less than fifty rats. Twenty-four of these were grocers' shops, sweet-meat sellers or grain stores, nineteen were weavers, eight were tailors' shops. No other trade seems to possess any influence especially favourable to rat infestation.

Cats and rat infestation.

Endeavours were made to get as accurate a cat census as possible of the city and the Sadar Bazaar. It was hoped that we should be able to get some figures that would express the value of the cat as a means of keeping down the rat population. We will state at once that the difficulty of getting reliable figures was very considerable. In the first place there are a good many ownerless cats that frequent a house or houses where they get food. There is some risk of counting some of these cats twice over. The second difficulty was due to the suspicious attitude of the people who seemed to imagine that we required all the information that we were seeking for some purpose connected with taxation. More than once we found them deliberately giving us false information. In spite of these difficulties we believe that the following figures possess a fair degree of accuracy.

It would appear that at the present time cats are very numerous in the Sadar Bazaar and comparatively scarce in the city. In the city, with a population of 23,885 there were only 314 cats. In the Sadar Bazaar with a population of 3500 there are 282 cats. In spite of this fact plague was, as we have shown above, more severe in the Sadar Bazaar than in the city, during the epidemic under report, and this we ascribed to the greater rat population in the Sadar Bazaar (vide p. 467).

In the city in 124 houses that possessed one or more cats the number of rats caught was 1187, an average of 9·5 rats per house. In 1799 houses that contained no cats 19,497 rats were caught, an average of 8·3 per house.

In the Sadar Bazaar in 119 houses that contained one or more cats, the number of rats caught was 902, an average of 7·5 rats per house. In 251 houses that contained no cats, 2175 rats were caught, an average of 8·6 rats per house.

These figures seem to show that the ordinary Indian cat is not a factor of any great value in keeping down the rat population.

Approaching the problem from a different standpoint, we found that 263 houses out of a total of 3813 inhabited houses kept cats. In these 263 houses there were 19 cases of plague, *i.e.* one in fourteen. In the 3550 houses that kept no cats there were 277 plague cases, an average of one in thirteen. The amount of protection that was offered by cats was therefore very small indeed.

TABLE V.

Census of Belgaum.

	City	Sadar Bazaar
Total number of houses	4927	793
Do. inhabited	3813	642
Do. uninhabited...	1114	151
Population	23885	3507
Number of houses in which rats were caught	2422	370
Number of rats	20684	3077
Average number of rats per house	8·5	8·3
Number of houses that contained buffaloes, bullocks, cows, ponies, or goats	1112	82
Number of such animals	3280	180
Number of houses containing such animals in which rats were caught	623	42
Number of rats	5738	402
Number of houses not containing such animals in which rats were caught	1799	328
Number of rats	14946	2675
Number of plague cases in houses that contained such animals	85	11
Number of plague cases in houses not containing such animals	211	56
Number of houses that contain cats	263	267
Number of cats	314	282
Number of houses containing cats in which rats were caught	124	119
Number of rats	1187	902
Number of houses not containing cats in which rats were caught	2298	251
Number of rats	19497	2175
Number of plague cases in houses that contain cats ...	19	21
Number of plague cases in houses that contain no cats ...	277	46

TABLE VI.

Type of house	Houses in which more than twenty but less than fifty rats were caught	Houses in which more than fifty but less than one hundred rats were caught	Houses in which more than one hundred rats were caught
Dwelling houses			
Brahmin	4	—	—
People in "service"	40	4	—
Coolies	33	1	—
Native Doctors	4	—	—
Pensioners	3	—	—
Agriculturists	34	4	—
Students	2	—	—
Pleaders	3	—	—
Beggars	1	—	—
Sweepers	1	—	—
Priest	1	—	—
Houses in which trades are carried on			
Sweetmeat shop	5	—	—
Tailors	8	—	—
Grocers	11	2	1 (197 rats)
Weavers	18	1	—
Grain merchants	7	1	—
Hotel keepers	3	—	—
Goldsmiths	5	—	—
Basket makers	6	—	—
Soda water shop	2	—	—
Farrier	2	—	—
Leather worker	3	—	—
Oil merchants	5	—	—
Carpenter	1	—	—
Potter	1	—	—
Barber	1	—	—
Fish dealer	1	—	—
Bone dealer	1	—	—
Wood merchant	1	—	—
Silk spinner	1	—	—
Tobacco seller	1	—	—
Betal nut seller	1	—	—
Vegetable shop	1	—	—
Liquor shop	1	2	—
Butcher	—	1	—
Stables	3	1	—
Unclassified	22	—	—
Totals	237	17	1

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