XXV. OBSERVATIONS IN THE PUNJAB VILLAGES OF DHAND AND KASEL.

I. INTRODUCTORY.

I. INTRODUCTION.

The villages selected for the present series of observations were Dhand and Kasel in the Amritsar District of the Punjab. They are situated about 10 miles south-west of Amritsar City and within a distance of $\frac{3}{4}$ mile of each other. They are typical Punjab villages of about 2,000 and 4,000 inhabitants respectively.

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They were selected for the present observations for the following reasons:—

(*a*) Their comparative isolation and limited amount of communication with other villages and towns rendered it possible to follow the movements of the villagers and any visitors.

(*b*) Since plague first appeared in the Amritsar District in the spring of 1902, both the villages had suffered from three epidemics. The disease in the villages showed a marked seasonal prevalence, a period of rise and decline and subsequent complete disappearance, and this periodicity especially called for study.

(*c*) Finally, as the inhabitants in previous years had shown themselves, as compared with those of other villages, amenable to any plague measures suggested, it was thought that they would render assistance to the Commission.

II. Description of the Villages.

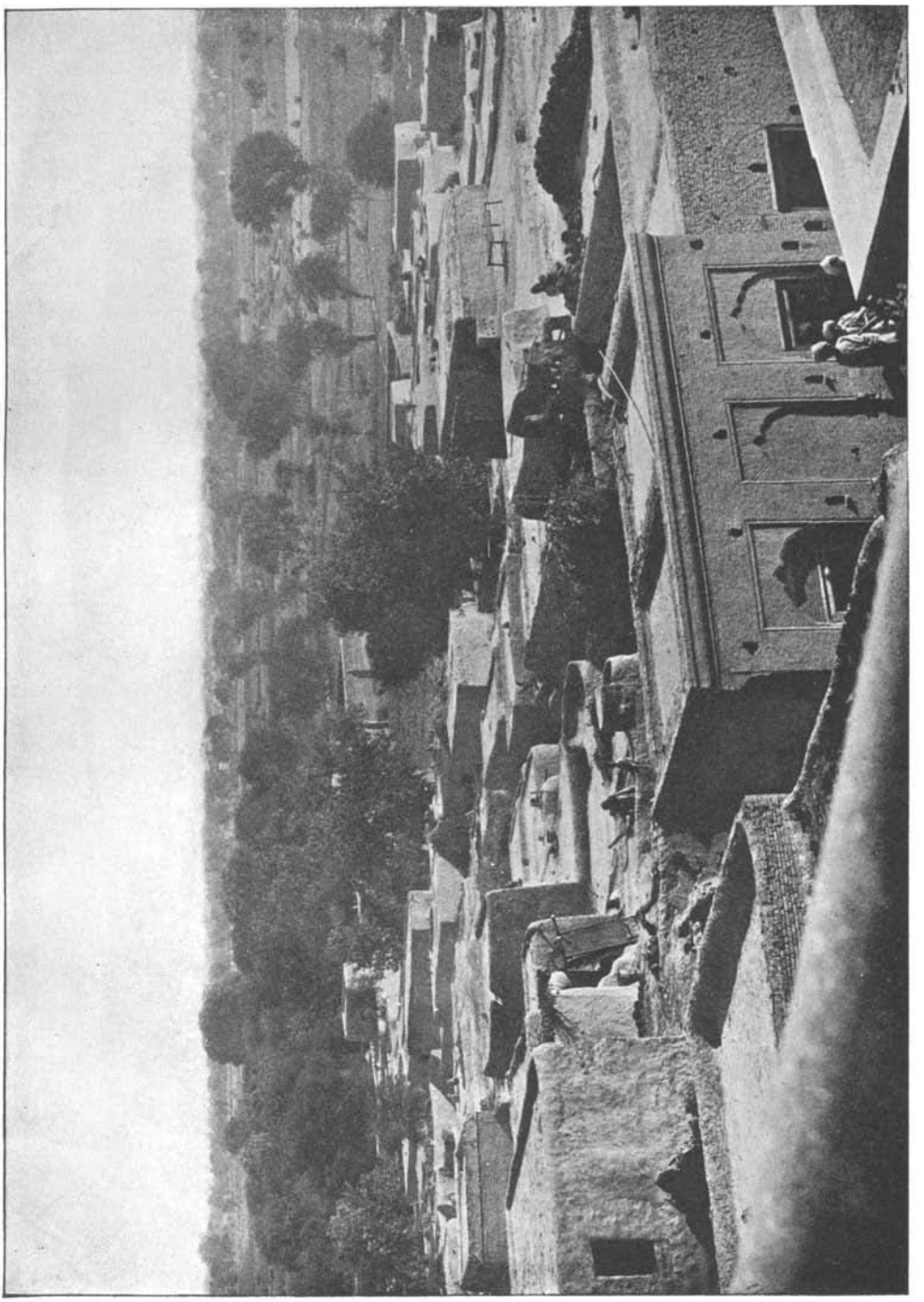
We propose to begin by giving a general description which applies to both villages and subsequently to give a special description and the census details for each village separately.

1. *General description.*

The following description is, with a few modifications and additions, taken from the excellent account of a Punjab village in Captain A. H. Bingley's book on Sikhs[1].

The Punjab village (Plate XXXV) is almost always composed of houses built of sun-dried bricks or of large clods of caked-mud, taken from the bottom of a pond. But there are few villages which do not contain one or two fire-baked brick buildings (*vide* Plate XXXVI), the home of a well-to-do headman, of the village money-lender, or, perhaps, of a pensioned native officer. The houses, crowded as closely as they can be, are separated by narrow, winding lanes often only a few feet wide. Those of a "patti" or ward lie together and often have a separate entrance with a gateway. Between the actual buildings and the cultivated fields is an open space running right round the village, sometimes shaded by pipal trees and almost always in a very insanitary condition. Carts, which would take up too much room in the village stand there, and there it is that the cane press will be seen at work in the winter.

[1] *Handbooks for the Indian Army: Sikhs.* Simla, 1899.



Kasel village.

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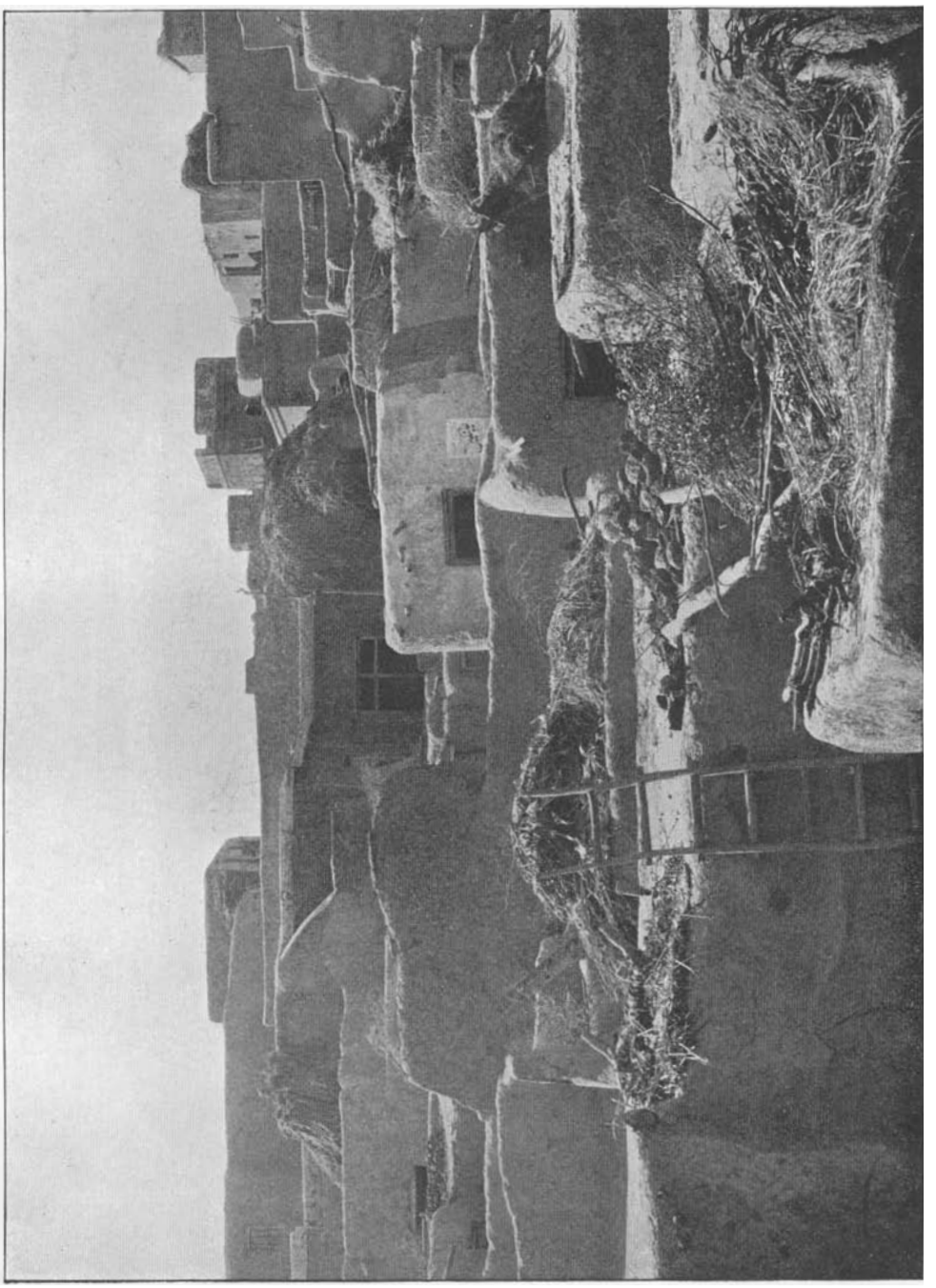

Kasel village.

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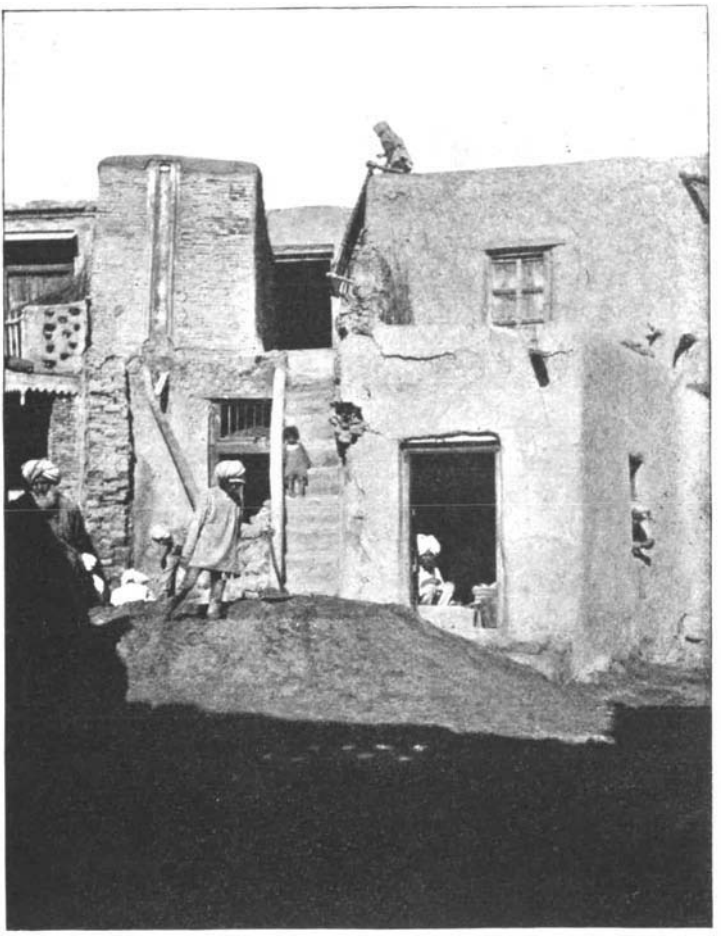

Kasel village.

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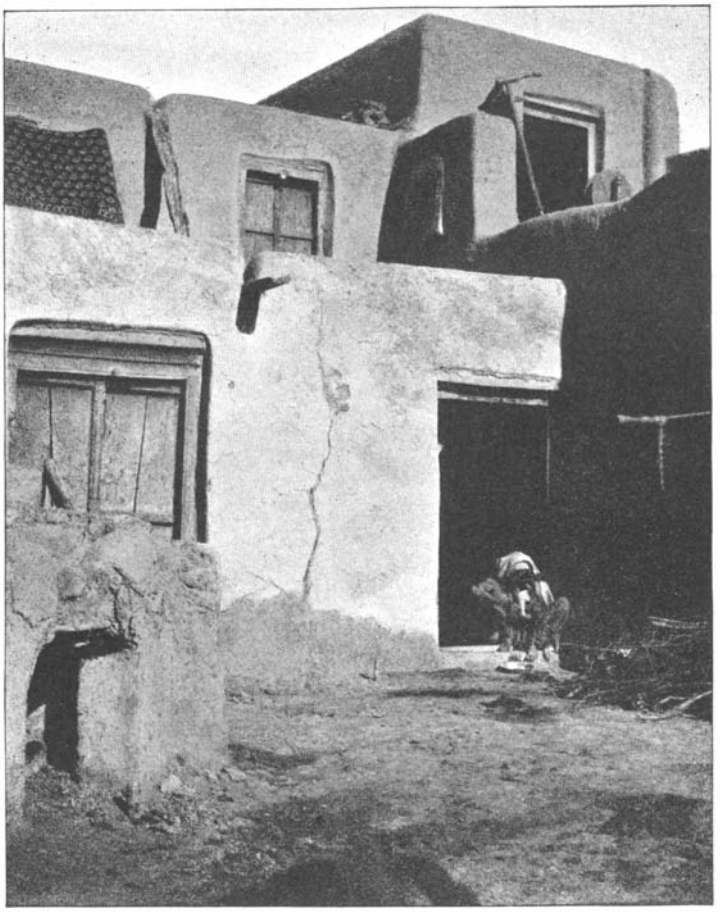

Kasel village.

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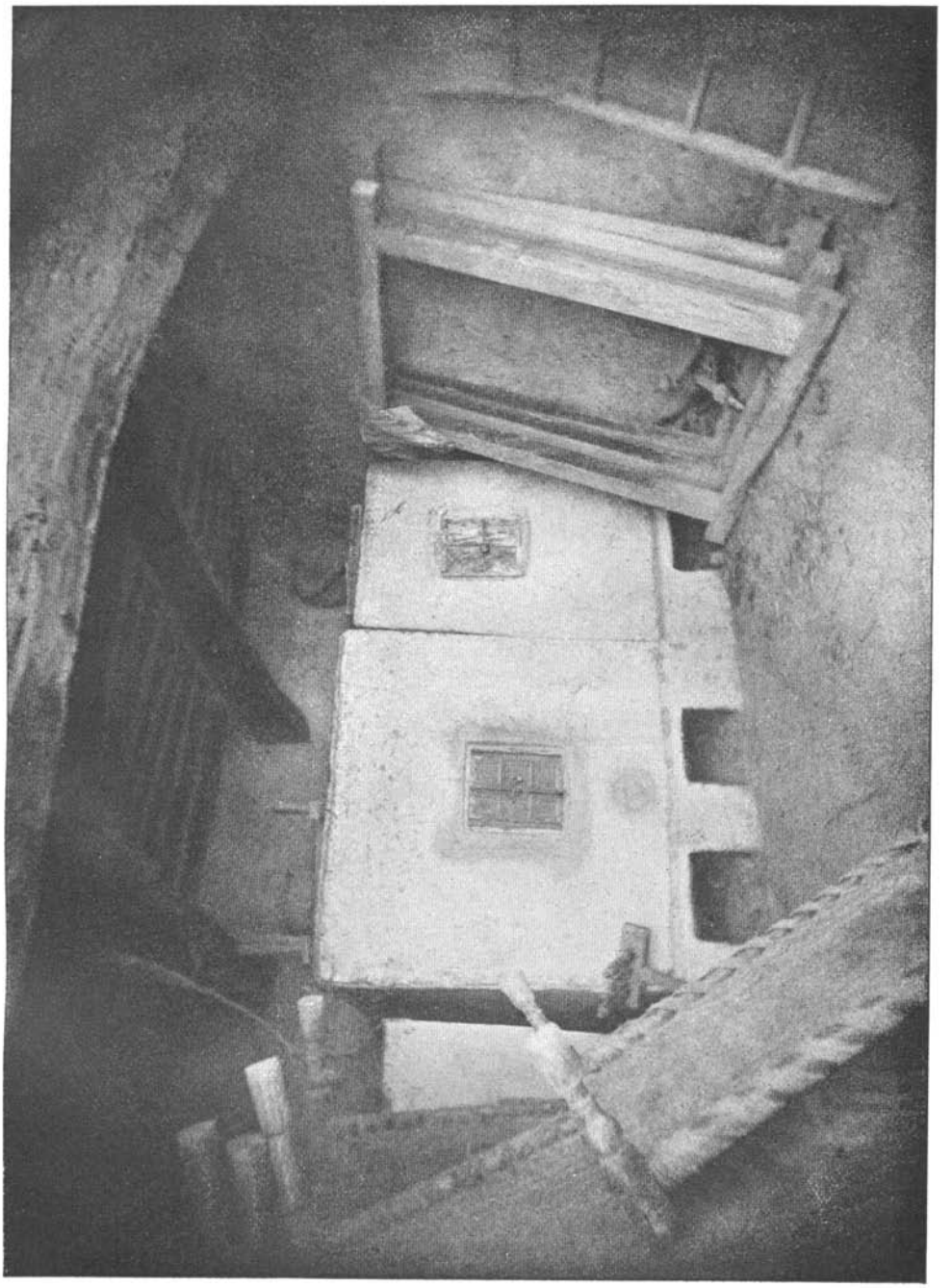

Kasel village: interior of house with "kothi."

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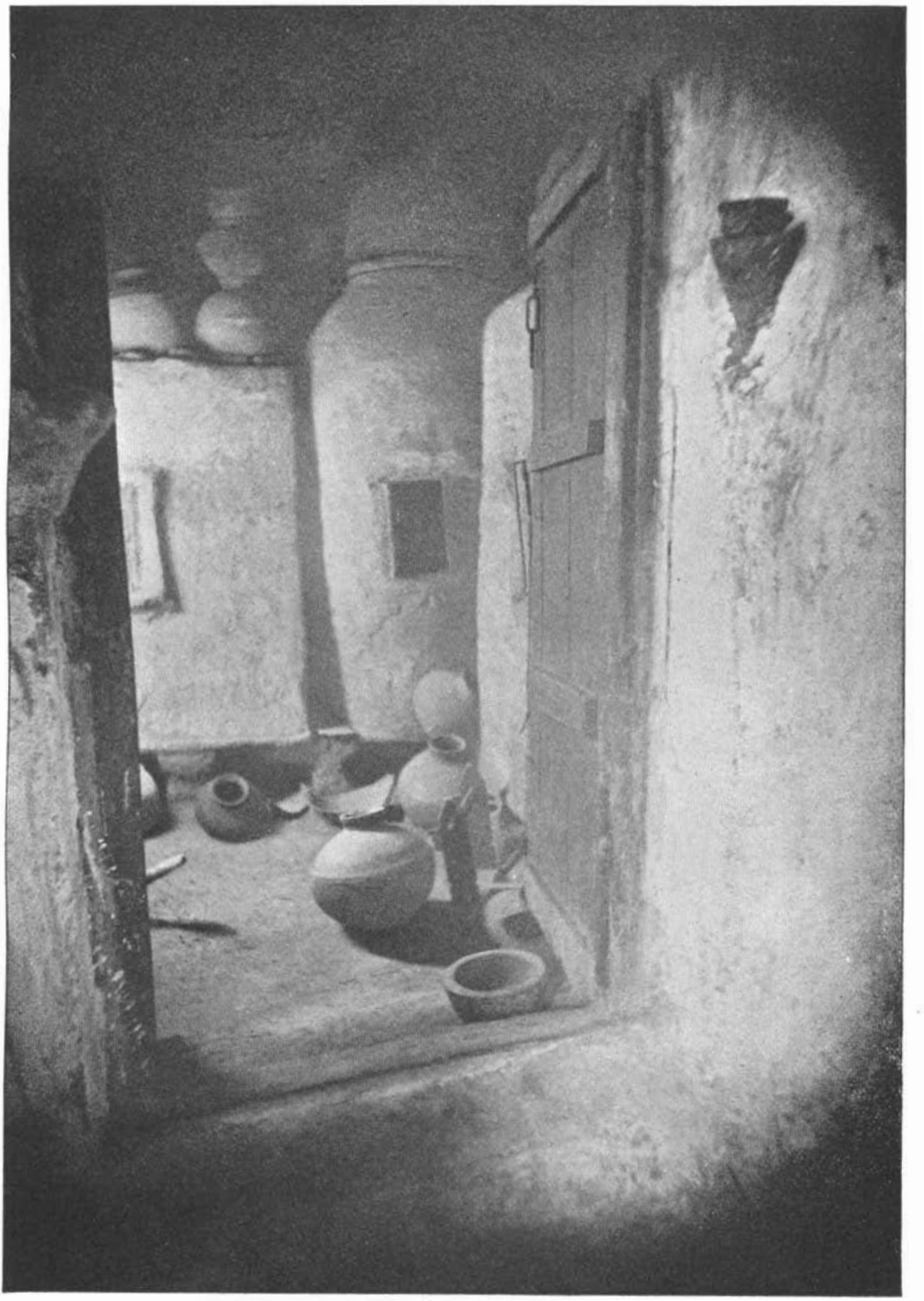

Kasel village: interior of house with "bharola" and "gharas."

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At one or more sides of the village are ponds, from which earth has been excavated for the repair of houses and in which cattle are bathed and watered.

The backs of the houses are usually blank walls forming an outer boundary to the settlement.

In the space surrounding the village are found the manure heaps and stacks of cowdung fuel belonging to each household.

Entering the village we find the doorways of the houses opening on the main street or on side lanes running off them. Ordinarily these doorways lead straight into an open court yard, with cattle troughs along one or more of its sides. The dwelling-house proper will generally be found along the side of the courtyard which fronts the doorway.

The dwelling-houses are long and narrow, with or without a small verandah in front called a "dalan," and are generally provided at one side with a flight of stairs or a wooden ladder giving access to the roofs (Plate XXXVII). Windows there are none; light and air are admitted by the door, and the smoke finds its way out by the same way, or perhaps by a hole in the roof.

Cooking is carried out for the most part in a partially roofed shelter in a corner of the courtyard, for the people live as much as possible in the open air and are only driven indoors by cold or rain.

A noticeable feature in every house is the receptacles for grain, made of plastered mud. These vary in shape; the commonest type is an oblong cupboard (kothi), raised about a foot from the ground with a space of about six inches between it and the adjoining house wall and furnished with a small wooden door for putting in and removing the grain (Plate XXXIX).

Another form of corn-bin is a large jar-shaped receptacle (bharola) (Plate XL).

The families dwelling within one courtyard as a rule are related to one another and belong to the same caste.

Each family living within the courtyard has a separate dwelling-house and cooking place, while in the yard, outside the doors, much of the available space is taken up by the "charpoys" (string beds) and water-pots of the household and the spinning wheels and grindstones of the women. The roof is used for storing heaps of jowar (grain), fodder and bundles of cotton twigs which are used for roofing purposes, also for drying chillies, Indian corn, etc., in the sun.

Occasionally there is a small upper room (chaubara) on the roof (Plate XXXVIII), but this is rare in most villages.

Sometimes the front door, instead of leading directly into the court, leads into a lodge or "deorhi," out of which a smaller door, placed so that the interior of the yard cannot be seen from the street, leads into the yard itself. The "deorhi" serves as a cart-house, tool-shed and stable, and also as a lodging for such guests as are not sufficiently intimate to be taken into the house.

2. *Construction of the houses.*

To the above description it is only necessary to add some account of the construction of the houses.

The mud walls are from $1\frac{1}{2}$ to 2 feet thick and in single storeyed houses average about 10 feet in height. Resting on the top of the walls are large rough-hewn beams ("shatir"), which support the roof (see Plate XXXIX). Lying across these beams are smaller rafters (karian), which in their turn support either bundles of cotton twigs or "sirki" (split cane), matting or cane.

The roof is completed by a layer of beaten earth from six to eight inches thick, which is immediately supported by the twigs, matting or cane. In the case of mud-built (kutcha) houses the walls are not sunk, but in brick and masonry houses they extend to a depth of from one to seven feet below the ground level. In both classes of houses the floor consists merely of beaten earth, which may or may not be plastered with cowdung (leeped).

Only very exceptionally is the floor raised above the general ground level. The upper storey, when it exists, often consists of a single room built on the middle of the roof and furnished with windows on all four sides (hence the Punjabi name for an upper story, "chaubara," meaning four entrances). These upper rooms thus afford a striking contrast in the matter of ventilation to the rooms on the ground floor.

3. *Ventilation.*

It will be apparent from the above description of the village house that, except in the upper storeys, no means for ventilation, except the doors, exist. The villagers sleep indoors from November to March with closed doors during the colder months, and the vitiation of the atmosphere is obvious on entering a house in the early morning.

Excluding storerooms and rooms for cattle, and taking into account only rooms actually occupied, we found the number of square feet of floor space per occupant to be in Dhand 50 and in Kasel 40. These

figures compare favourably with those for Bombay and other large Indian cities.

4. *Disposal of excreta.*

The adult inhabitants resort to the fields outside the village for purposes of defecation. Young children, and adults confined to their houses by illness, pass their excreta into an earthen vessel or on to the actual floor of their houses or court yards. In either case the faeces are removed outside the village by sweepers.

5. *Circumstances in the houses favouring rats.*

These may be considered under the headings of (*a*) accessibility; (*b*) food-supply.

(*a*) *Accessibility.* We have seen that the large majority of village houses are built either of sun-dried bricks or of large clods of caked-mud. These mud walls, as well as the mud floors and roofs, present no obstacle to the rat, which burrows freely in all three.

(*b*) *Food-supply.* As mentioned above every Punjab house contains its granary (kothi, bharola, etc.). The well-to-do cultivator, after the spring harvest, stores sufficient wheat for the needs of his household for the entire year in his granaries, cellars and storerooms, while the Kamin classes receive in return for their services several months' supply. In all the houses there is thus abundant grain kept in places more or less accessible to rats. In addition to wheat, which is the staple foodstuff of the villagers, numerous other varieties of grain, flour, sugar, ghee (clarified butter), potatoes, onions, etc. are kept in earthen vessels (gharas), of which large numbers are to be seen in every village house (*vide* Plate XL). On several occasions we have received from villagers rats which have been caught alive in these vessels, where they had gone in search of food.

6. *Village officials.*

As in the description of the methods adopted for studying plague in these villages we shall have to refer to the various agencies which we utilised for obtaining information about plague rats and cases, it is necessary here to give a short description of the village officials who gave us assistance.

The Zaihldar is a native official in charge of a collection of six to ten villages, termed a Zaihl. He is responsible for the collection of the

revenue in his Zaihl and the carrying out of all orders, sanitary or otherwise, emanating from the Tahsil[1].

Under the Zaihldar are two or more officials, termed "Safed Posh," each of whom is directly in charge of a subdivision of the Zaihl, consisting of a group of three or more villages.

The Zaihldar and Safed Posh are head lumbardars of their own villages, and we were fortunate in having these two influential persons residing the one in Kasel and the other in Dhand.

Coming to the individual village we find that each is subdivided into two or more "pattis" or wards. Each ward is in charge of a recognised official called a "lumbardar," the head lumbardar of a village being termed the "ala lumbardar." Each lumbardar is responsible for the collection of the land revenue and hearth-tax in his own patti.

They are assisted in their duties by the village "chowkidars." The latter (chowkidars) are village menials, usually Mahomedans of a caste called Barwalas. There is one to each "patti." Their chief duties are to report cases of crime to the nearest police station, to report births and deaths in their respective pattis to the lumbardars who enter them in their village registers and to assist the latter in collecting revenue.

Lastly, we have to refer to the village "Patwaris." These officials are paid by Government to keep accounts of land and revenue. They are trained in survey work and proved most useful in making maps of the villages to scale. Their thorough knowledge of the inhabitants and their relatively high standard of education and intelligence enabled them to be of great assistance to us in making a census of the village.

It will be evident from the above description of the village officials, that there already existed in both villages an agency, capable of exercising a very complete supervision over the inhabitants; and through the kindness of the Civil authorities we were permitted to make full use of it.

7. *Census operations.*

The first step taken was to number every house. For this purpose we defined a house as a domicile occupied by a family which had a common cooking place. For instance, when, as commonly happens, several brothers and their families occupy adjoining houses in the same courtyard and each family cooks separately, each house received a separate number.

[1] A District in the Punjab for administrative purposes is divided into Tahsils, each of which, as we have seen, is made up of Zaihls.

For convenience of reference, numbers were also given to stables, shops and unoccupied houses, which strictly speaking do not come within the above definition of a house.

Having completed the numbering of the houses, a detailed map to scale (100 feet to 1 inch) of each village was prepared by the Patwaris. These maps showed every house with its number. A complete census of each village was then made, full particulars for each house being recorded on special "Census Cards." These particulars included the name, age, sex, caste and occupation of every inhabitant.

Further, an estimation of the amount of space available per occupant was made for each house. Probable sources of attraction for rats, such as the proximity of cattle sheds or grain and chaff stores to the dwelling-houses, were noted.

Finally, with a view of ascertaining how far plague tends to recur in particular houses full particulars of the previous incidence of plague in each house were obtained and noted on the cards.

III. Methods adopted for Studying the Epizootic and Epidemic.

1. *Observations on the rats.*

(*a*) *Live rats.*

A systematic examination of the rats in the villages was carried out. Every evening numbered traps were set by the village chowkidars in different houses, the census numbers of the houses being, as far as possible, followed consecutively. The traps were removed in the morning under the immediate supervision of a Hospital Assistant, who made out a list of the trap numbers and the corresponding house numbers.

On arrival of the traps at the laboratory a count of the fleas on the rats was made with as little delay as possible. The traps were placed in pairs in tin-lined boxes with closely fitting lids and containing two compartments, each fitted with a removable tray on which the trap rested. Chloroform was shaken over the traps and the boxes were closed. After a sufficient interval the traps and trays were removed, and the fleas which had fallen on the tray were counted as well as those adhering to the fur of the dead rats. The total number of fleas found on the rat or rats in each cage was thus obtained and was noted in a special register. They were examined as regards the species to which they belonged, and a note of any *Ceratophyllus fasciatus* found was made. During several months of the period over which the observations extended an attempt was made to obtain a count of the relative numbers

of fleas found on different anatomical regions of the rat, viz. (*a*) the head and neck, (*b*) chest, axilla and fore-legs, and (*c*) abdomen, groins and hind-legs. For this count we could, of course, only take into consideration the fleas which were found on the rats after their removal from the chloroform box.

After the fleas had been removed and counted the rats were weighed and a label was attached to each. On this label the serial number, the date, the number of the house in which the rat was caught and the weight of the rat were noted.

The rats were then pinned out (*vide* Plate XLI) for dissection. The post-mortem examination was carried out in the way which has already been described for the Bombay rats. The cutting-up was done by two Hospital Assistants, trained to recognise the post-mortem appearances of plague rats. Every rat dissected was examined by a Member of the Commission, who also made a microscopical examination of smears from the spleen of every rat.

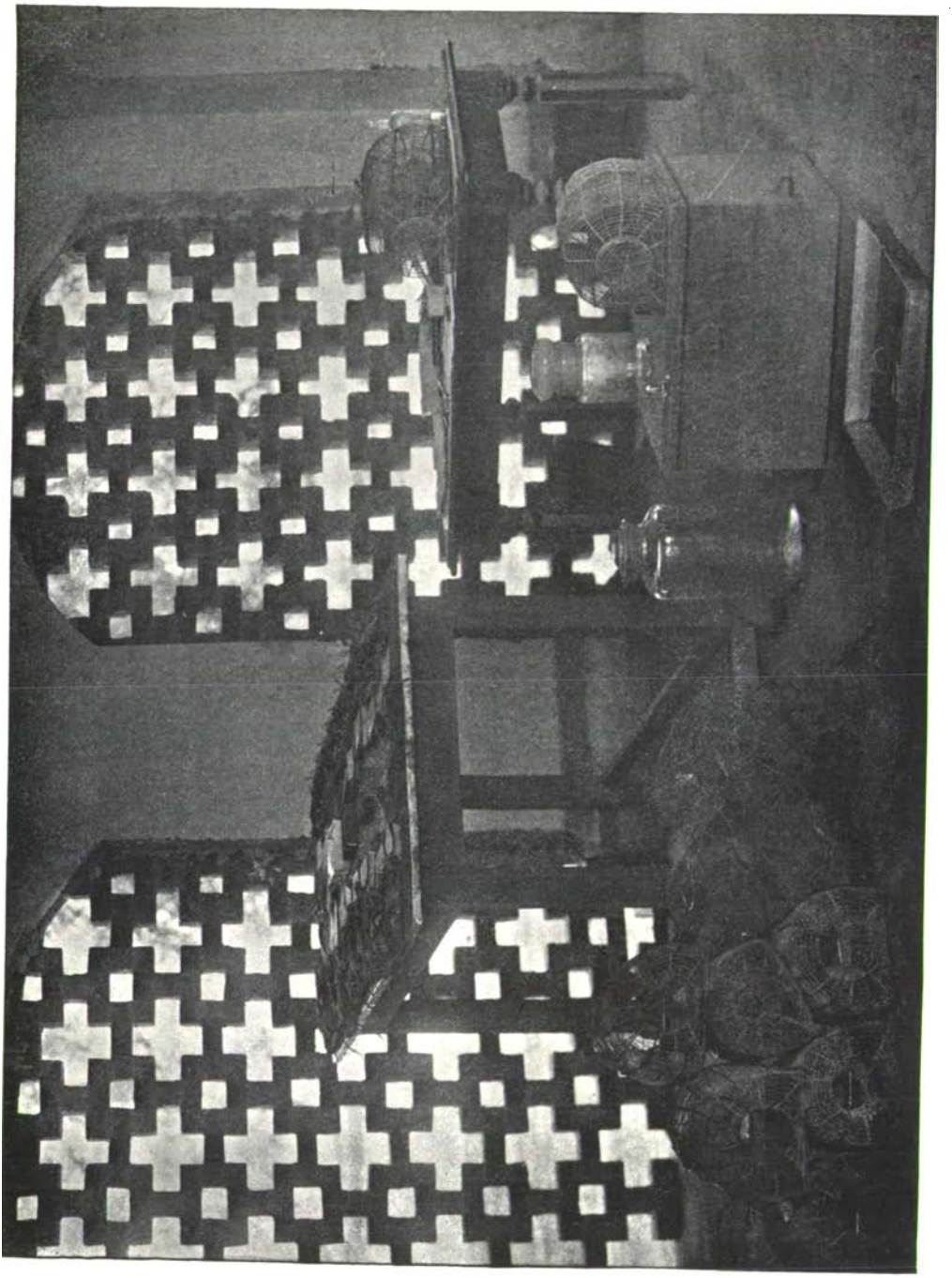
Animal and cultural tests were used when the diagnosis was uncertain. The results of this examination, including particulars as to sex, pregnancy and infection with plague, were now entered on the label.

At the conclusion of each day's work the details noted on the labels were copied into a rat register in serial order. In the case of plague-infected rats the result of the post-mortem examination and the other details were recorded on the cards ("plague rat cards"), which were used in Bombay and which have been already described.

(*b*) *Dead rats.*

While systematic trapping was being carried out in the way detailed above, we made every effort to secure all the dead rats that were to be found in the village. The villagers were advised through the lumbardars to send us any dead rats they might find, and we promised to let them know whether they proved to be plague infected or not, so that in the event of the animals proving plague infected they might take precautionary measures, such as evacuation of their houses or inoculation. It was, however, carefully explained to them that under no circumstances would they be compelled to undergo inoculation or have their houses disinfected nor would they be compelled to evacuate them. The chowkidars made daily inquiries for dead rats in their respective pattis. During the epizootic they were provided with tins with closely fitting lids, in which they brought all dead rats to the laboratory.

The post-mortem examination of the dead rats and other details were recorded in the same way as was done in the case of the live rats.



The Punjab Laboratory.

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2. *The epidemic.*

It was realised that, unless we obtained the confidence of the people before the epidemic broke out, concealment of plague cases would certainly occur. It was, therefore, decided to open a small free dispensary at the laboratory, which the villagers were encouraged to attend. This measure met with considerable success, the daily attendance soon averaging from 15 to 20.

Further, all cases of illness about which we received information were visited and treatment was offered. As a result the people had grown quite accustomed to our presence among them by the time the epidemic broke out and concealment of plague cases was quite exceptional. When the relations of the patient did not themselves report the case to the chowkidar or lumbardar of their patti, information was usually quickly received from the neighbours.

At first it was intended that an attempt should be made to confirm the diagnosis of all cases by bacteriological methods, and this was actually done for the first few cases which occurred in Dhand. It was soon recognised, however, that any attempt to obtain material for examination as a routine measure would defeat its own object by leading to concealment of cases, as the patients and their relatives often naturally objected to the somewhat painful operation of puncturing the bubo in its early stage, though they were quite ready to have it incised when pus had formed. This procedure was, therefore, abandoned and the diagnosis of most of the cases was based on the clinical features, which were usually sufficiently typical. In a few instances where the patients were adult females examination of the inguinal regions for buboes was not permitted, and we had to rely on the statements of the patient and her friends.

3. *Co-relation of epizootic and epidemic.*

The details of all plague rats were entered at the laboratory on the special "plague rat" cards already referred to. On the same evening or the next morning these cards were taken to the village, where the addresses already noted on them were checked by a Member of the Commission, and all further particulars were entered in the cards under their appropriate headings. After the addresses had been checked each plague rat was marked in its proper position on the map and the date affixed. Similarly, every human case of plague reported was seen as soon as possible and, if diagnosed to be plague, full particulars

were noted on a "Human case card," which was of the same pattern as that used in Bombay. Special attention was directed to ascertaining the probable place of infection, where this was not obviously the place of residence. The plague cases, like the plague rats, were entered on the map with the date of attack. When the probable place of infection was other than the place of residence the case was shown by a different symbol in both places.

II. RATS AND FLEAS.

I. Observations on the rat population.
  (1) Remarks on the animals examined.
  (2) Observations in connection with *Mus rattus*.
    (*a*) Species.
    (*b*) Habits.
    (*c*) Breeding.
    (*d*) Migration.
    (*e*) Normal mortality.
    (*f*) Post-mortem appearance of plague rats.
    (*g*) Diseases other than plague among rats.
    (*h*) Rat infestation of the villages.

II. Observations on the fleas infesting the rats.

I. Observations on the Rat Population.

1. *General remarks on the animals examined.*

During the period during which the observations continued, namely, from 29th November 1905 to 30th November 1906, the total number of *Mus rattus* examined from Dhand and Kasel was 7525, of which 7164 were trapped alive and 361 were delivered dead at the laboratory. Plague was identified in 52 live and 290 dead rats. No *Mus decumanus* were found.

In addition to the above rodents the following animals were examined:—5 mice, 19 musk rats (*Crocidura coerulea*), 9 gerbils (*Gerbillus indicus*) and 25 *Nesokia bengalensis*. Out of these one mouse and one musk rat were found infected with plague. The musk rat was found dead in Kasel during the epizootic. All the musk rats and 7 of the gerbils were obtained in the villages, most of the latter from houses on the outskirts. The two remaining gerbils and all the *Nesokia* were taken in the fields at harvest time. The absence of *Nesokia* in the interior of the villages is noteworthy, as this species

appears to be common in Calcutta and by no means rare in Bombay City.

The small number of mice caught may in part be accounted for by the traps used being unsuitable for catching this species. Inquiries in the villages, however, appear to show that mice are not commonly seen in houses.

2. *Observations in connection with Mus rattus.*

(*a*) *Species.* The rats taken in the Punjab villages were all of one species, namely *Mus rattus*. The type resembles very closely that found in Bombay, which has been already described. The colour of the dorsal fur is usually brown, while the belly is greyish, dirty-yellow or occasionally quite white. The fur during the cold weather is longer and thicker than that of the *Mus rattus* found in Bombay.

(*b*) *Habits.* *Mus rattus* in the Punjab, as in Bombay, is essentially a house rat. We have seen that the houses in a Punjab village are well adapted for harbouring this animal, both on account of the abundant grain supply and on account of the facilities for burrowing which the mud walls and floors offer. It is indeed the exception to find a village house which does not show evidence of rat infestation, such as rat holes and rats' dung. In illustration of the close relation that exists between rat and man, it may be mentioned that a common complaint of the villagers is that their sleep has been disturbed by rats running over them at night.

In contrast with *Mus rattus* in Bombay city, the Punjab rat burrows extensively. In this respect he resembles *Mus decumanus* in Bombay, as also in the peculiarity that his nests are always found in the burrows. We have never found rats' nests actually in the houses, *i.e.* among rubbish collected in the rooms. This is a situation in which rats' nests are commonly found in Bombay. It is almost certain that the rat-burrows in the Punjab villages are very extensive, ramifying beneath and opening up communication between several contiguous houses. On two occasions we have actually traced burrows in the walls of houses which were in process of being pulled down. These burrows, which contained mummified rats, extended the entire length of the wall, as far as we could open it up and into the wall of an adjoining house, where we could not follow them.

(*c*) *Breeding.* An attempt was made to ascertain if there is any special breeding season of *Mus rattus* in the Punjab. The same method was adopted as was used in Bombay. The number of pregnant females

and the number of young (70 grammes and under) rats were recorded each day. The percentage of pregnant females to adult females and of young rats to total rats was calculated for each month. The results are given in Tables I and II, in which the figures for Dhand and Kasel are combined. The figures showing the percentage of pregnant females among adult females refer to live rats only, while the corresponding figures for young rats include both dead and live rats (see also chart 1).

TABLE I.

Showing percentage of pregnant females among total adult females—Dhand and Kasel.

Mus rattus—alive.

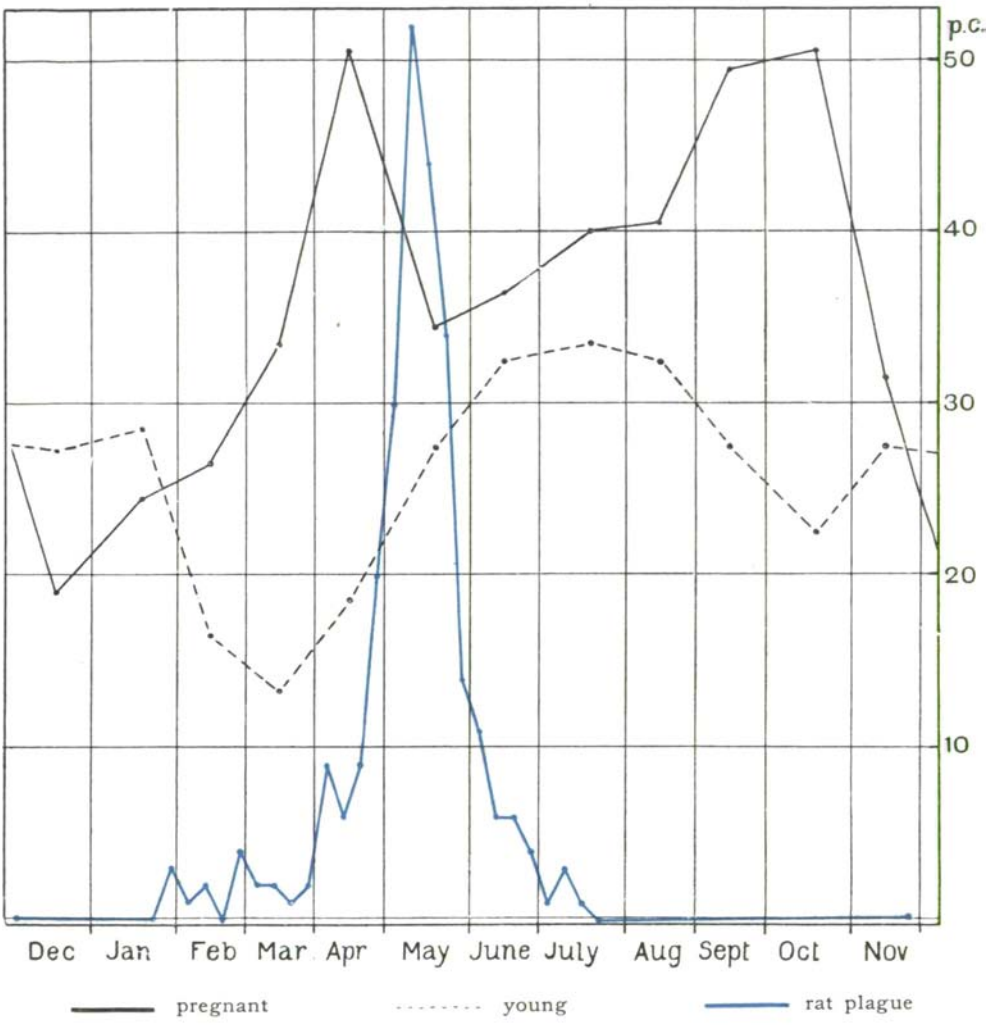
Month	Total adult live females	Total adult pregnant females	Percentage of pregnant to total adult females
December	668	126	18·9
January	293	71	24·2
February	266	70	26·3
March	461	154	33·4
April	145	73	50·3
May	142	49	34·5
June	94	34	36·2
July	50	20	40·0
August	84	34	40·5
September	152	75	49·3
October	131	66	50·4
November	334	105	31·4

TABLE II.

Showing percentage of young rats among total rats—Dhand and Kasel.

Mus rattus—live and dead.

Month	Total rats alive and dead	Total young rats alive and dead	Percentage of young rats on total rats
December	1842	503	27·3
January	824	234	28·4
February	670	108	16·1
March	1037	136	13·1
April	408	76	18·6
May	486	132	27·2
June	259	84	32·4
July	143	48	33·6
August	234	76	32·5
September	373	102	27·3
October	370	83	22·4
November	879	241	27·4



Breeding of Mus rattus in Kasel and Dhand

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From the tables and the chart it will be seen that breeding goes on all the year round. The lowest percentage of pregnant females among adult females was about 19 in December and the highest about 50 in April, September and October, the mean percentage for the whole period being 31. The curve of pregnant females shows a maximum in April and again in September and October. In this connection it may be remarked that the mean temperature of April does not differ much from that of September and October.

Interpreting the curve broadly, we may say that during the cold weather months (November to March inclusive) breeding takes place to a less extent than during the hot weather, and that the most favourable months are April, September and October, when the mean temperature approximates to 80° F.

The curve of young rats follows as closely as could be expected the pregnant female curve.

The number of foetuses in utero was counted in 975 pregnant rats, the average number found being 6 per rat.

(*d*) *Migration.* An attempt was made to determine by direct experiment whether any migration of rats from villages takes place. With this object traps were placed during January and part of February outside Kasel village, at distances varying from a few yards to two hundred yards from the houses. In all 940 traps were set, and in one instance only, when the traps were placed closed to a house, were a few *Mus rattus* caught. When trapping was resumed in Kasel towards the end of February, we were obliged to discontinue the trapping outside the village. The above experiment is not conclusive, as it was done during the cold weather and at a time when there was no plague amongst the rats in the village. It is, therefore, probable that at this time there would be little tendency of the rats to migrate.

The statement has been made by some workers on plague, that at the time the harvest is cut (April—June), rats leave the village and go into the fields, and on this basis an attempt has been made to explain the seasonal decline of the epidemic. We may say that we failed to obtain any evidence that such a migration takes place. The only animals at all resembling *Mus rattus* which we found in the fields during the harvesting of the spring crops in April, May and June, were specimens of *Nesokia bengalensis.* The superficial resemblance of this rodent to *Mus rattus* probably accounts for the idea of some of the farmers that rats migrate from the villages to the fields. On the other hand, the more intelligent cultivators recognise the distinction between

these two species and emphatically deny that rats ever leave the village. It may be mentioned that the epizootic in Kasel coincided in point of time with the harvest months.

(*e*) *Normal mortality.* Table III shows the number of rats found dead in the villages from causes other than plague. In addition to rats proved to be plague infected, all putrid rats found during the epizootic period, in which plague was not negatived, are excluded. It will be seen that only 116 such dead rats were found during the year. It seems certain that this number cannot represent the normal rat mortality and it may, therefore, be inferred that the large majority of rats which die from normal causes die in inaccessible places.

TABLE III.

Showing the number and post-mortem appearances of rats found dead in Dhand and Kasel from causes other than plague during the 12 *months ending* 30*th November* 1906.

Post-mortem appearances	No. of rats
Nothing naked eye or on microscopic examination	57
Signs of injury	26
Putrid but not proved by animal test to be plague infected	15
Oedema of neck	1
Abscess of lung	1
Tumours	1
Granular spleen or liver; subcutaneous congestion; pleural or peritoneal effusion; or other appearances suggesting death from plague, but not confirmed by animal tests	15
Total	116

NOTE :—A considerable number of these rats were found infected with trypanosomes.

The interesting question arises, whether the number of plague rats found above ground bears a similarly small proportion to the total number which die of plague. During the epizootic period 226 dead plague rats were found in Kasel, while during the same period only 23 rats which had died from other causes were discovered.

Assuming that the chances of finding dead plague rats and non-plague rats are equal, it might be argued that during the epizootic the rat mortality from plague in Kasel was 10 times the normal mortality.

It was impossible to extend the search for plague rats into the burrows, as this would have involved much damage to the houses. Hence we cannot bring forward any direct evidence as to the number

which die in their burrows. However, on the two occasions on which we had the opportunity of opening up rat burrows in the walls, mummified carcases of rats were found in them, and the villagers say that they are very commonly found when houses are being pulled down.

(*f*) The post-mortem findings in acute plague rats in Bombay have been already described (vol. VII., p. 324): the results obtained in the Punjab were the same (see Tables IV, V, VI). The morbid anatomy of the chronic plague rats in the Punjab has been detailed above (vol. VII., p. 457).

TABLE IV.

Showing the frequency of the common post-mortem signs in the acute plague rats found during the epizootic in Kasel (252) *and Dhand* (34).

	Kasel	Dhand
Subcutaneous congestion	142 (56 p.c.)	19 (56 p.c.)
Granular liver	63 (25 p.c.)	17 (50 p.c.)
Granular spleen	43 (17 p.c.)	9 (26·5 p.c.)
Pleural effusion	191 (76 p.c.)	17 (50 p.c.)
Haemorrhages, subcutaneous and elsewhere	176 (70 p.c.)	18 (53 p.c.)

TABLE V.

Showing the analysis of the results of the microscopical examination of the bubo, spleen, and heart's blood of the acute plague rats found during the epizootic.

		Dhand	Kasel
Bubo	No *B. pestis*	2 (11·1 p.c.)	11 (7·1 p.c.)
	Few ,,	4 (22·2 p.c.)	12 (7·8 p.c.)
	Numerous ,,	12 (66·7 p.c.)	113 (73·4 p.c.)
	Involution forms	0	18 (11·7 p.c.)
Spleen	No *B. pestis*	13 (38 p.c.)	31 (12·4 p.c.)
	Few ,,	2 (6 p.c.)	6 (2·4 p.c.)
	Numerous ,,	18 (53 p.c.)	184 (73·6 p.c.)
	Involution forms	1 (3 p.c.)	29 (11·5 p.c.)
Heart's blood	No *B. pestis*	11 (39·3 p.c.)	64 (26·5 p.c.)
	Few ,,	3 (10·7 p.c.)	26 (10·7 p.c.)
	Numerous ,,	14 (50 p.c.)	149 (61·6 p.c.)
	Involution forms	0	3 (1·2 p.c.)

(*g*) *Diseases, other than plague, amongst the rats.* Apart from plague the commonest pathological conditions found in Punjab rats were peripheral abscesses. The organism most frequently isolated from these abscesses was a very small diplo-bacillus, which gave a feeble growth on agar and usually could not be subcultured. This bacillus was non-pathogenic to guinea-pigs. As about 60 % of these abscesses

TABLE VI.

Showing the distribution of the primary bubo in the acute plague-infected rats found during the epizootic.

	No bubo	Single bubo					Multiple buboes				
KASEL:—	98 (39·9 p.c.)	131 (52 p.c.)					23 (9·1 p.c.)				
		Neck	Groin	Axilla	Pelvic	Supra-condyloid	Neck + Axilla	Neck + Groin	Neck + Axilla + Groin	Axilla + Groin	Groin + Pelvic
		67 (51·1 p.c.)	28 (21·4 p.c.)	33 (25·2 p.c.)	2 (1·5 p.c.)	1 (0·8 p.c.)	10 (43·5 p.c.)	5 (21·8 p.c.)	2 (8·7 p.c.)	3 (13 p.c.)	3 (13 p.c.)
DHAND:—	14 (73·9 p.c.)	19 (55·9 p.c.)									
		Neck	Groin	Pelvis	Axilla						
		14 (73·9 p.c.)	2 (10·5 p.c.	1 (5·2 p.c.)	2 (10·5 p.c.						

were found in connection with superficial lymphatic glands, it seemed possible that they might have originated as plague buboes and have undergone a secondary infection with the bacillus above described. It was found, however, that the distribution of these glandular abscesses differed somewhat from that of plague buboes found in Punjab rats, as may be seen by reference to Table VII.

TABLE VII.

Comparison of distribution of buboes in plague rats and of chronic abscesses occurring in situation of lymphatic glands but not containing B. pestis.

Situation	Plague buboes		Chronic abscesses not containing *B. pestis*	
	number	percentage	number	percentage
1. Single	150	86	81	100
a. Submaxillary	81	54	42	52
b. Axillary	36	24	7	9
c. Inguinal	30	20	30	37
d. Pelvic	3	2	2	2
2. Multiple	23	14	0	0

TABLE VIII.

Showing percentage of Mus rattus found infected with Adie's Leucocytozoon, each month.

Month	No. of rats examined	No. of rats infected	Percentage of rats infected
December 1905	1823	306	16·8
January 1906	843	123	14·6
February	707	50	7·1
March	1051	43	4·1
April	451	3	0·7
May	574	31	5·4
June	352	79	22·4
July	598	130	21·7
August	505	109	21·6
September	504	97	19·2
October	879	147	16·7
November	1212	191	15·8
Total	9499	1309	13·8

The other diseases met with include a very few cases of abscess of the lung, abscess of the liver, "acid fast" disease, ovarian and other abdominal tumours. Trypanosomes were commonly found, especially in young rats. Another common blood parasite found was the leucocytozoon recently described by Adie (*Journal of Tropical Medicine*, 1906,

vol. IX. p. 325). A daily record of the number of rats in the spleen of which this parasite was found was kept. At the end of the observations it was found that the percentage of rats infected for the entire year was 14. Table VIII shows the percentage found infected during each month of the year. We have no reason to suppose that this parasite is pathogenic.

(*h*) *Rat infestation of the villages.* Tables IX and X show the extent of the rat infestation of the two villages during each month, as indicated by the number of rats taken per 100 traps. It will be seen that in Kasel the total number of *Mus rattus* trapped in the complete year was 4639 or an average of 1·2 rats per inhabitant. The corresponding figures for Dhand are 2518 and 1·3 per inhabitant. In Kasel the majority of houses were trapped 10 times and in Dhand 17 times during the year.

TABLE IX.

Showing the results of rat trapping in Dhand month by month.

Month	No. of traps set	No. of rats taken	Average No. of rats per 100 traps
December 1905	943	742	80
January 1906	2393	801	34
February	1699	258	15
March	1492	141	10
April	436	21	5
May	534	17	3
June	936	28	3
July	—	—	—
August	—	—	—
September (14 to 30)	233	78	34
October	301	149	50
November	875	283	32
Entire year	9842	2518	26

It is somewhat difficult to compare the relative extent of rat infestation of the two villages. A reference to the tables shows that the average number of rats caught per 100 traps for the whole year was 54 in Kasel as compared with 26 in Dhand. But if we seek to conclude from these figures that the rat infestation of Kasel was originally double that of Dhand, we are met by the objection that the relatively heavier trapping in Dhand throughout the year must have tended to reduce the average number of rats taken per 100 traps for the whole period, as, other factors being equal, the catch must have diminished with each successive trapping. For the same reason we cannot express the relative

rat infestation of the two villages in terms of the number of rats taken per inhabitant. On the whole the best approximation would seem to be obtained by comparing the number of rats taken per 100 traps in each village during the first complete trapping. These numbers are for Kasel 148 rats per 100 traps and for Dhand 96, from which we infer that at the time we commenced the observations in the villages the rat infestation of Kasel was about 50 % higher than that of Dhand.

TABLE X.

Showing the results of rat trapping in Kasel, month by month.

Month	No. of traps set	No. of rats taken	Average No. of rats per 100 traps
December 1905	782	1080	138
January 1906	—	—	—
February (20 to 28)	448	398	89
March	1260	870	69
April	586	316	54
May	927	315	34
June	1048	202	19
July	772	132	17
August	774	232	30
September	619	292	47
October	531	215	40
November	854	587	69
Entire year	8601	4639	54

Tables IX and X further show that for several months after trapping was commenced its effect was to reduce progressively the number of rats caught. Later, however, although trapping was continued, the numbers caught began steadily to increase, showing that breeding was able to more than compensate for the loss sustained by trapping. The effect of the plague epizootic on the number of the rat population will be discussed fully in a later paper on the seasonal prevalence of plague.

During November 1906 in Kasel the average number of rats caught per 100 traps set was 69 or exactly half the corresponding number for December 1905. In other words, the apparent rat population had been reduced by one half during the year. Assuming that the rat population of the village for any given months in the off-plague season remains fairly constant from year to year (breeding and mortality from all causes balancing each other), this reduction of the rat population may be taken to be due to trapping. The total number of rats trapped

was roughly 5000, and we have seen that the removal of this number reduced the apparent rat population to about one half. Hence, we can roughly estimate the original rat population at 10,000. On a similar estimate the rat population of Dhand would be originally about 4000. These figures would not include rats under 10 grammes weight, as we have not trapped any below this weight.

Table XI shows the rat infestation of Kasel as a whole and the relative infestation of different classes of houses, etc. The average number of rats taken per occupied house (*i.e.* occupied by a single family) for the entire period was 5·2, and the number of rats per 100 traps sets for the same class of houses 53·8. An analysis of the figures for 21 "pukka" (brick and mortar) houses shows that they do not differ appreciably from "kutcha" (mud) houses as regards rat infestation. It is to be noted, however, that the brick and mortar houses in the village resemble the other (kutcha) houses in having floors of beaten earth. As might have been expected from the abundant supply of grain which they contain in accessible situations, shops show a high degree of rat infestation. The degree of infestation of stables, unoccupied houses and godowns is relatively low.

TABLE XI.

Showing rat infestation of Kasel as a whole and the relative infestation of different classes of houses, stables, etc.

	Description of house, etc.	No. of houses trapped	No. of traps set	No. of rats caught	Average No. of rats per 100 traps	Average No. of rats per house, stable, etc.
1	All kinds	1084	8642	4711	54·5	4·3
2	Occupied dwelling houses (all kinds)	783	7545	4059	53·8	5·2
3	Occupied dwelling houses (Pukka masonry)	21	290	142	50·0	5·8
4	Stables	137	416	149	35·8	1
5	Unoccupied houses	83	307	137	44·6	1·7
6	Shops	49	260	321	123·5	6·6
7	Godowns	32	114	45	39·5	1·4

II. Observations on the Fleas infesting the Rats.

The bionomics and the anatomy, both external and internal, of the fleas found in association with rats in India are dealt with in other papers. It will be sufficient here to briefly mention the species of fleas found on Punjab rats and the seasonal prevalence of each species.

1. *Pulex cheopis.* In the Punjab, as in Bombay, the common rat flea is *Pulex cheopis*, 98% of the fleas found on *Mus rattus* belonging

to this species. We have also commonly found this flea on musk rats and occasionally on gerbils caught in the village houses.

Tables XII and XIII show the average number of fleas of this species per rat caught for each month from December 1905 to November 1906 in Dhand and in Kasel. It will be seen that the maximum flea prevalence in Dhand was in February and in Kasel during April. It is

TABLE XII.

Showing average number of fleas (P. cheopis) per rat month by month in Dhand.

Month	Total No. of live rats on which fleas were recorded	Total No. of fleas	Average No. of fleas per rat
December 1905	704	5037	7·2
January 1906	803	9025	11·2
February	258	3220	12·5
March	141	1302	9·2
April	20	251	12·5
May	17	100	5·9
June	28	95	3·4
July	—	—	—
August	—	—	—
September	78	157	2·0
October	152	751	5·0
November	281	2633	9·4
Total	2482	22571	9·1

TABLE XIII.

Showing average number of fleas (P. cheopis) per rat month by month in Kasel.

Month	Total No. of live rats on which fleas were recorded	Total No. of fleas	Average No. of fleas per rat
December 1905	927	6987	7·5
January 1906	6	60	10·0
February	389	3038	7·8
March	879	6767	7·7
April	330	4145	12·6
May	324	2382	7·4
June	204	1036	5·1
July	136	514	3·8
August	226	447	2·0
September	296	696	2·4
October	223	1204	5·4
November	586	4147	7·1
Total	4526	31423	6·9

remarkable that February and April were the first months of the epizootics in Dhand and Kasel respectively. Owing, however, to the small numbers of rats received from Dhand from April to August inclusive and from Kasel during January and part of February, it is not possible to compare the seasonal flea prevalence in the two villages. For the same reasons we are perhaps not justified in considering that the months of maximum flea prevalence really differ in the two villages as the February figures for Kasel are incomplete and the April figures for Dhand are calculated on 21 rats only.

Table XI and Chart 2 which show the figures of the two villages combined may, however, be considered to fairly represent the variations in flea prevalence from month to month. From a study of this chart and table we may, without laying too much stress on minor variations, draw certain general conclusions. Thus the number of rat fleas is above the average from November to May with a maximum probably in April. During the remaining months, June to September, the flea prevalence is below the average, the absolute minimum being reached in August and September, when the number per rat is 6 times less than in April.

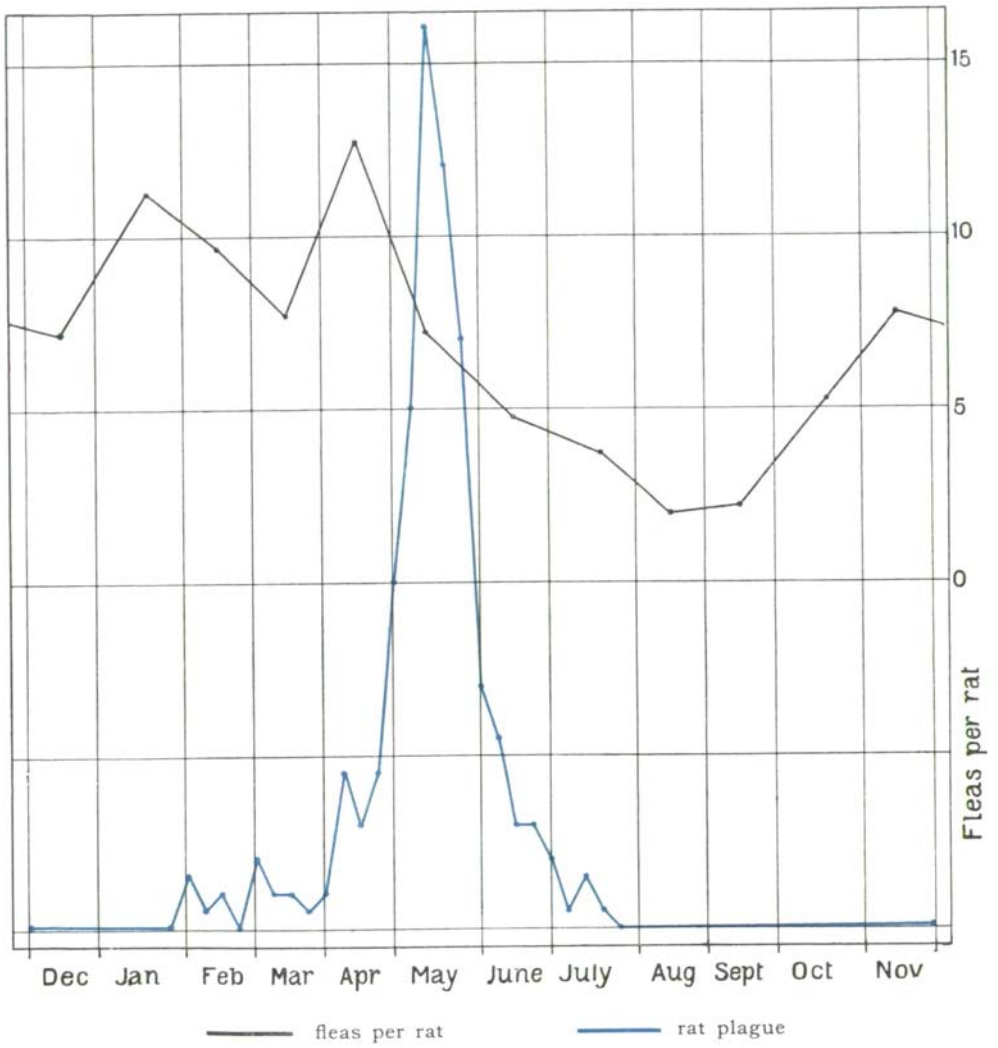
The influence of this seasonal variation of fleas on the seasonal prevalence of plague will be fully dealt with in another paper.

TABLE XIV.

Showing the average number of fleas (P. cheopis) per rat month by month in Dhand and Kasel.

Month	Total No. of live rats on which fleas were recorded	Total No. of fleas	Average No. of fleas per rat
December 1905	1631	12024	7·4
January 1906	809	9085	11·2
February	647	6258	9·7
March	1020	8069	7·9
April	350	4396	12·6
May	341	2482	7·3
June	232	1131	4·9
July	136	514	3·8
August	226	447	2·0
September	374	853	2·3
October	375	1955	5·2
November	867	6780	7·8
Total	7008	53994	7·7

2. *Ceratophyllus fasciatus.* About 2% of all the fleas taken on Punjab rats belong to this species. This flea has a very definite



Prevalence of Pulex cheopis in Kasel and Dhand

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seasonal prevalence in the villages investigated. It was found to be present on the rats in both villages when we commenced observations in the beginning of December 1905. It disappeared from Dhand about the end of March and from Kasel about the middle of April, except for an isolated specimen found in May. From this date no fleas of this species were found till the first week in November, when they reappeared almost simultaneously in both villages, and until trapping was stopped in the first week in December they remained present. Table XV shows the number of *Ceratophyllus* caught during each month and their percentage of total fleas. It is evident that the season during which this flea is found on rats extends from November to April. We have seen already that *Pulex cheopis* also is most prevalent during these months.

TABLE XV.

Showing prevalence of Ceratophyllus fasciatus in Dhand and Kasel for each month.

Month	No. of *C. fasciatus*		Percentage on all fleas		Average No. per live rat.	
	Kasel	Dhand	Kasel	Dhand	Kasel	Dhand
December 1905	record not complete	record not complete	—	—	—	—
January 1906	village not trapped	298	—	3·4	—	0·4
February	82	70	2·7	2·2	0·2	0·3
March	289	35	4·3	2·7	0·35	0·25
April	14	—	0·3	—	0·04	—
May	1	—	—	—	—	—
June	—	—	—	—	—	—
July	—	—	—	—	—	—
August	—	—	—	—	—	—
September	—	—	—	—	—	—
October	—	—	—	—	—	—
November	112	11	2·7	0·5	0·2	0·04
December	17	—	2·5	—	0·2	—

III. OBSERVATIONS WHICH HAVE SPECIAL REFERENCE TO THE VILLAGE OF DHAND.

I. Introduction.
  (1) Situation, etc.
  (2) Census results.
II. Previous epidemics of plague.
III. The plague epidemic of 1906.
  (1) Period before the epidemic.
  (2) Period during the epidemic.
    (*a*) Severity and duration of the epidemic.
    (*b*) Clinical features of cases.
      1. Nature of the cases.
      2. Situation of the primary bubo.
      3. Mode of onset.
      4. Sex incidence.
      5. Age incidence.
      6. Caste incidence.
      7. Case mortality.
    (*c*) Distribution of the cases amongst the houses.
    (*d*) Contact with previous cases.
IV. The epizootic.
  (1) Period before the epizootic.
  (2) Period during the epizootic.
  (3) Period after the epizootic.
  (4) Origin of the epizootic.
  (5) Severity and extent of the epizootic.
V. Relation between the epizootic and the epidemic.
  (1) Relation in time.
  (2) Relation in place.

I. Introduction.

1. *Situation.*

Dhand is the smaller of the two Punjab villages in which the observations on rat and human plague were carried out. It is situated about eight miles south-west of Amritsar city, with which it has communications by a cart track. The main road from Gharenda to Tarn-Taran passes through the village (*vide* Map 1) dividing it into two parts, a northern part, called the "old village," and a southern portion, the "new village." It is built on practically level ground and covers an area of about 27 acres.

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2. *Census results.*

The population according to our census was 1920, and the density of population about 70 per acre. The structure of the houses and of the village generally corresponds to the description already given and it is, therefore, only necessary to add a few census details.

The number of occupied houses is 418. Of these, 121 contain a single room, 105 two rooms and 192 more than two rooms. 110 of the houses are two storeyed, the upper storey usually consisting of a single room. Of the occupied houses only 13 are brick and masonry structures, the remainder being built of sun-dried bricks or clods of caked mud.

The inhabitants may be classified as under:—

Sikhs and Hindus	932
Mahomedans	737
Chuhras	251

It would serve no useful purpose to describe the subdivisions of these groups, but it may be mentioned that the first two groups comprise about twenty distinct castes, most of which have different occupations. While the bulk of the population follows agriculture as a pursuit, the village community includes a large number of persons of the artisan and menial classes, called Kamins, who in return for their services receive a share of the produce of each harvest.

II. Previous Epidemics of Plague in Dhand.

Plague first appeared in Dhand in May, 1902, within two months of its first introduction into the Amritsar District. Six deaths from the disease are recorded to have occurred in May and June of that year. The disease seems to have died out in June and did not reappear till early in November, 1902, when it quickly assumed epidemic proportions. This, which may be taken as the first epidemic, lasted till the middle of March, 1903. There were in all 153 attacks with 81 deaths.

After an interval of nearly 11 months, during which the village remained free from plague, the second epidemic started early in February, 1904, and lasted till the second week of May, 1904. The number of attacks was 376 and of deaths 241.

After another plague-free interval of about 11 months, plague reappeared in April, 1905. The epidemic of that year was a comparatively mild one—47 attacks and 21 deaths. The last recorded death from plague occurred on the 14th July, 1905.

No reliable information could be obtained as to how plague was first introduced into the village in May, 1902, nor as to the probable source of origin of the subsequent epidemics. The result of our inquiries leaves no doubt, however, that during all three epidemics dead rats were found in more or less intimate connection with plague cases.

III. The Plague Epidemic of 1906.

1. *Period before the epidemic.*

We have seen that the last death from plague in 1905 occurred on the 14th July. From the end of November, when the Commission commenced its observations in the village, a careful watch was kept on the health of the people, as has been indicated above. No case of plague came to light until the 6th February, 1906.

2. *Period during the epidemic.*

(*a*) *Severity and duration of epidemic.*

The epidemic of 1906 consisted of 32 cases. The date of attack of the first case was the 6th February and of the last case the 2nd May (Table XIX).

A list of the cases and a short description of each will be found in the Appendix.

(*b*) *Clinical features of the cases.*

1. *Nature of the cases.* Of 27 cases in which a complete examination was made, 25 were of the bubonic form, the other two having no buboes. The remaining five patients were adult females, who would not allow an examination for buboes, but stated that none were present.

2. *Situation of the bubo.* The situation of the bubo in the 25 bubonic cases examined was as follows:—

Femoral	15
Axillary	5
Cervical	3
Femoral and Cervical	1
Femoral, Axillary and Cervical	1

3. *Mode of onset.* In 16 cases pain in the gland with or without swelling was amongst the earliest symptoms. In three cases the bubo developed on the day following the onset of fever and other symptoms;

in one case after 2 days, in one case after 4 days, in two cases after 5 days and in one case after 6 days.

4. *Sex incidence.* Table XVI shows the relative proportion of males and females which were attacked. It is seen that the incidence on females was considerably higher than that on males.

TABLE XVI.

Showing the incidence of attacks on males and females in Dhand.

	Total population	Plague attacks	Incidence per 1000
Males	1037	13	12·5
Females	883	19	21·4

5. *Age incidence.* Table XVII shows the relative incidence on persons at different age periods. While the figures relating to the plague attacks are too small to draw any very definite conclusions, it is seen that the very young and the old are less liable to attack than persons of other ages.

TABLE XVII.

Showing the relative incidence of attacks on persons at different age periods in Dhand.

Age period	Total population	Plague attacks	Incidence per 1000
0—5 years	347	1	3
6—10 ,,	263	9	34
11—20 ,,	391	8	20
21—40 ,,	601	11	18
Over 41 ,,	318	3	9

6. *Caste incidence.* We have already seen that the population can be divided into three very distinct castes. The plague incidence on these three castes is shown in Table XVIII, from which it is seen that the sweepers and menials suffered rather less than the Mahomedans, and the Mahomedans less than the Hindus and Sikhs.

TABLE XVIII.

Showing the plague incidence on different castes in Dhand.

Caste	Total population	Plague attacks	Incidence per 1000
Sikhs and Hindus	932	18	19
Mahomedans	737	11	15
Chuhras (menials)	251	3	12

7. *Case mortality.* Out of 32 cases, 19 or almost exactly 60% ended fatally. The longest interval between the onset of the illness and death was 20 days and the shortest one day; the average for the 19 fatal cases was from four to five days.

(*c*) *Distribution of cases among houses.*

The 32 cases inhabited 26 houses. Of these one house furnished three cases, four houses furnished two cases each and 21 houses a single case each. Multiple cases in a house were, therefore, uncommon.

All the cases were treated in their own houses for the whole course of their illness. In the 21 houses which furnished single cases the number of contacts was 86, all of whom came into intimate relation with the cases.

(*d*) *Contact with previous cases.*

We were able definitely to ascertain that 25 (80 %) of the cases did not, prior to attack, come in contact with other plague cases (*vide* Appendix), namely: cases *A* to *D*, *F*, *G*, *K* to *S*, *U*, *V*, *X* and *Z* to *FF*. The remaining seven cases, *E*, *H*, *I*, *J*, *T*, *W*, and *Y*, had come in contact with preceding plague cases, so we cannot exclude the possibility of their having been directly infected from the latter. The great majority of cases, however, cannot have received their infection from a previous case.

IV. The Epizootic.

1. *Period before the epizootic.* (Map 2.) (From 4th December, 1905, to 26th January, 1906.)

During this period 1481 *Mus rattus* were examined at the laboratory, of which 1474 had been trapped and seven were found dead. While none of these rats were shown to be suffering from acute plague, four live rats were found to have chronic abscesses, from which *B. pestis* was recovered. The first of these chronic plague rats was trapped on the 18th December and the last on the 11th January, *vide* Map 2.

As the subject of chronic rat plague has been discussed in a separate paper (Vol. VII. p. 457) we need only point out here that in all four rats *B. pestis* was apparently localised in the abscesses and that there was no evidence that it was present in any of the organs or in the heart-blood.

2. *Period of epizootic.* (Map 1 and Maps 3—16.) (From 27th January, 1906, to 21st April, 1906.)

During this period 542 rats were examined of which number 514 were caught alive and 28 were found dead. Plague was identified in 12 live rats and in 22 dead rats.

MAP 1

DHAND VILLAGE, PUNJAB

Showing all the plague infections

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DHAND VILLAGE, PUNJAB

Showing all the plague infections

Scale 100 *feet to half-an-inch*

- Human plague case (serial letter)
- Plague infected rat (serial number)
- Free guinea-pig died of plague
- Fleas taken in house transmitted plague to guinea-pig in laboratory
- Both and

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MAP 2

DHAND VILLAGE, PUNJAB

29 Nov. 1906 to 26 Jan. 1906

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DHAND VILLAGE, PUNJAB

Period before the epizootic, 29 Nov. 1905 to 26 Jan. 1906

Scale 100 *feet to half-an-inch*

● Plague infected rats, all chronic (date)

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MAP 3

DHAND VILLAGE, PUNJAB

27 Jan. 1906 to 2 Feb. 1906

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MAP 3

DHAND VILLAGE, PUNJAB

First week of epizootic, 27 Jan. 1906 to 2 Feb. 1906

Scale 100 *feet to half-an-inch*

● Plague infected rat (date)

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MAP 4

DHAND VILLAGE, PUNJAB

3 Feb. 1906 to 9 Feb. 1906

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DHAND VILLAGE, PUNJAB

Second week of epizootic, 3 Feb. 1906 to 9 Feb. 1906

Scale 100 *feet to half-an-inch*

Human plague case (date of attack)

Plague infected rat (date)

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MAP 5

DHAND VILLAGE, PUNJAB

10 Feb. 1906 to 16 Feb. 1906

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DHAND VILLAGE, PUNJAB

Third week of epizootic, 10 Feb. 1906 to 16 Feb. 1906

Scale 100 *feet to half-an-inch*

Human plague case (date of attack)

Plague infected rat (date)

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MAP 6

DHAND VILLAGE, PUNJAB

17 Feb. 1906 to 23 Feb. 1906

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DHAND VILLAGE, PUNJAB

Fourth week of epizootic, 17 Feb. 1906 to 23 Feb. 1906

Scale 100 *feet to half-an-inch*

Human plague case (date of attack)

Plague infected rat (date)

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MAP 7

DHAND VILLAGE, PUNJAB

24 Feb. 1906 to 2 March, 1906

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DHAND VILLAGE, PUNJAB

Fifth week of epizootic, 24 Feb. 1906 to 2 March, 1906

Scale 100 *feet to half-an-inch*

● Human plague case (date of attack)

● Plague infected rat (date)

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MAP 8

DHAND VILLAGE, PUNJAB

3 March, 1906 to 9 March, 1906

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MAP 8

DHAND VILLAGE, PUNJAB

Sixth week of epizootic, 3 March, 1906 to 9 March, 1906

Scale 100 *feet to half-an-inch*

Human plague case (date of attack)

Plague infected rat (date)

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MAP 9

DHAND VILLAGE, PUNJAB

10 March, 1906 to 16 March, 1906

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DHAND VILLAGE, PUNJAB

Seventh week of epizootic, 10 March, 1906 to 16 March, 1906

Scale 100 *feet to half-an-inch*

● Plague infected rat (date)

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MAP 10

DHAND VILLAGE, PUNJAB

17 March, 1906 to 23 March, 1906

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DHAND VILLAGE, PUNJAB

Eighth week of epizootic, 17 March, 1906 to 23 March, 1906

Scale 100 *feet to half-an-inch*

Human plague case (date of attack)

Plague infected rat (date)

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MAP 11

DHAND VILLAGE, PUNJAB

24 March, 1906 to 30 March, 1906

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DHAND VILLAGE, PUNJAB

Ninth week of epizootic, 24 March, 1906 to 30 March, 1906

Scale 100 *feet to half-an-inch*

Human plague case (date of attack)

Plague infected rat (date)

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MAP 12

DHAND VILLAGE, PUNJAB

31 March, 1906 to 6 April, 1906

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DHAND VILLAGE, PUNJAB

Tenth week of epizootic, 31 March, 1906 to 6 April, 1906

Scale 100 feet to half-an-inch

● Human plague case (date of attack)

● Plague infected rat (date)

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MAP 13

DHAND VILLAGE, PUNJAB

7 April, 1906 to 13 April, 1906

MAP 13

DHAND VILLAGE, PUNJAB

Eleventh week of epizootic, 7 April, 1906 to 13 April, 1906

Scale 100 *feet to half-an-inch*

- Human plague case (date of attack)
- Plague infected rat (date)

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MAP 14

DHAND VILLAGE, PUNJAB

14 April, 1906 to 20 April, 1906

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DHAND VILLAGE, PUNJAB

Twelfth week of epizootic, 14 April, 1906 to 20 April, 1906

Scale 100 *feet to half-an-inch*

● Human plague case (date of attack)

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MAP 15

DHAND VILLAGE, PUNJAB

21 April, 1906 to 27 April, 1906

MAP 15

DHAND VILLAGE, PUNJAB

Thirteenth week of epizootic, 21 April, 1906 to 27 April, 1906

Scale 100 *feet to half-an-inch*

Human plague case (date of attack)

Plague infected rat (date)

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MAP 16

DHAND VILLAGE, PUNJAB

28 April, 1906 to 4 May, 1906

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DHAND VILLAGE, PUNJAB

Fourteenth week of epizootic, 28 April, 1906 to 4 May, 1906

Scale 100 *feet to half-an-inch*

● Human plague case (date of attack)

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MAP 17

DHAND VILLAGE, PUNJAB

5 May, 1906 to 3 December, 1906

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DHAND VILLAGE, PUNJAB

Period after the epizootic, 5 May, 1906 to 3 December, 1906

Scale 100 *feet to half-an-inch*

● Plague infected rat, chronic (date)

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The first acute plague rat was trapped in house No. 347 on the 27th January, *vide* Map 1, Serial No. 1, and Table XIX. This rat had no bubo or other post-mortem lesion but a smear from the spleen showed abundant *B. pestis*. Guinea-pig experiments done on the 29th January to determine if the house was infective gave negative results. On searching the house four mummified carcases of rats were found in a back room which had remained closed for over a year. This room showed other evidence of rat infestation, the floor being littered with rats' dung and the walls riddled with rats' burrows, apparently leading into an adjoining house No. 350.

The next three plague-infected rats were also trapped alive (Map 1, Serial Nos. 2, 3 and 4), on 30th January and 2nd February. The post-mortem appearances of all three suggested a subacute variety of plague and that the rats were recovering from the acute disease. One had a submaxillary purulent bubo which showed *B. pestis* in the pus. Of the other two, one had a granular liver and the other a granular spleen, but no *B. pestis* were seen in smears from the organs or heart-blood. In all three plague was identified by animal tests.

After an interval of a week two dead plague rats were found on the 9th February (Map 1, Serial Nos. 4 and 5). The former was found in a back room of house No. 350, which immediately adjoins house No. 347, where the first plague rat was trapped, and the latter in a lane some distance away. On the same date in another house adjoining 347, namely, No. 349, four mummified rats were found in a back room.

It is remarkable that, with the exception of the mummified rats referred to (which may or may not have been plague infected), not a single dead plague-infected rat was found until a fortnight after the first acute plague rat had been trapped. In this interval two persons had been attacked with plague, so that if we had depended for our information on the examination of dead rats only, we would have been led to a wrong conclusion as to the time relation of the epizootic and epidemic.

The further progress of the epizootic in Dhand can best be followed by referring to Map 1 and Table XIX, and the series of weekly Maps Nos. 3—16.

The mode of spread of the epizootic through the village was characterised by considerable irregularity. It cannot be said to have extended outwards from the original focus as a wave with a definite margin, leaving the area passed over free from infection for the rest of the epizootic period. On the contrary some plague rats were found at a

TABLE XIX.

Showing the places at which, and the first and last dates on which, plague-infected rats were taken. The entries are consecutively numbered in accordance with the dates on which the first infected rat was taken. References to the 32 human cases are inserted in the series in their chronological order.

No.	House No.	Infected rats taken: First	Last	Total
1	347	27/1/06	—	1
2	342	30/1/06	—	1
3	156	,,	—	1
4	350	2/2/06	9/2/06	2
	Case A attacked on 6/2/06 in House No. 352			
	,, B ,, 7/2/06 ,, ,, 349			
5	In lane *near* No. 377	9/2/06	—	1
	Case C attacked on 12/2/06 in House No. 340			
	Cases D and E attacked on 13/2/06 in House Nos. 498 and 338			
6	492	14/2/06	—	1
	Case F attacked on 16/2/06 in House No. 181			
	,, G ,, 22/2/06 ,, ,, 378			
7	439	23/2/06	14/3/06	2
	Cases H and I attacked on 24/2/06 in House No. 378			
8	466	26/2/06	—	1
9	501	,,	—	1
10	163	,,	—	1
11	364	27/2/06	—	1
	Case J attacked on 27/2/06 in House No. 340			
12	24	5/3/06	—	1
	Case K attacked on 5/3/06 in House No. 335			
13	178	6/3/06	—	1
14	57	9/3/06	—	1
15	321	12/3/06	—	1
16	Near No. 456	13/3/06	—	1
17	60	18/3/06	—	1
	Case L attacked on 22/3/06 in House No. 159			
18	318	23/3/06	—	1
19	15	24/3/06	31/3/06	2
	Case M attacked on 26/3/06 in House No. 401			
20	402	28/3/06	—	1
	Case N attacked on 28/3/06 in House No. 39			
	,, O ,, 29/3/06 ,, ,, 603			
1	137	31/3/06	3/4/06	2

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Case P attacked on 31/3/06 in House No. 456

No.	House No.	Infected rats taken		
		First	Last	Total
22	583	1/4/06	—	1
23	517	2/4/06	—	2
24	185	4/4/06	—	1
	Case Q attacked on 4/4/06 in House No. 225			
	,, R *imported* ill with Plague on 6/4/06 to House No. 85			
25	186	6/4/06	—	1
26	618	7/4/06	—	1
	Cases S and T attacked on 7/4/06 in Houses Nos. 3 and 225			
	,, U and V ,, 10/4/06 in House No. 622			
27	371	12/4/06	—	1
	Case W attacked on 12/4/06 in House No. 85			
	Cases X and Y attacked on 14/4/06 in Houses Nos. 587 and 589			
	Case Z attacked on 18/4/06 in House No. 122			
	,, AA ,, 19/4/06 ,, ,, 583			
	,, BB ,, 20/4/06 ,, ,, 588			
28	315	21/4/06	—	1
29	Near 408	,,	—	1
	Case CC attacked on 21/4/06 in House No. 2			
	,, DD ,, 23/4/06 ,, ,, 220			
	,, EE ,, 1/5/06 ,, ,, 386			
	,, FF ,, 2/5/06 ,, ,, 387			

considerable distance from the original focus of infection early in the epizootic, such as Nos. 7 and 12; while many of the later plague rats were found quite near the area where the epizootic had begun, pointing either to the persistence of infection in this area or to re-infection from more peripheral areas, *vide* Serial Nos. 15, 18, 21, 27, and 28. In spite, however, of these irregularities it may be admitted that the general direction of spread was centrifugal, and that the areas furthest from the original focus were the last to become infected. An instance of this is furnished by the southern part of the village, in which the first infected rat, Serial No. 22, was found on 1st April, more than two months after the origin of the epizootic.

Similarly the first evidence of the spread of the epizootic to the sweepers' quarters in the extreme north of the village was obtained by the finding, early in April, of infected rat fleas in house No. 225 in which case *Q* occurred.

3. *Period after the epizootic.* (Map No. 17.)

The last acute plague rats were taken on the 21st April 1906. From the 22nd April to the conclusion of the observations in Dhand on the 3rd December 1906, 592 rats were examined, of which 583 were trapped alive and nine were brought dead to the laboratory. On the 8th June a plague-infected live rat was taken (*vide* Map 17). This rat had a purulent submaxillary bubo and no other lesions. Smear preparations of the pus showed several clumps of plague-like organisms. A guinea-pig inoculated cutaneously with the pus died of plague in four days. No other plague-infected rat was found from this date to the conclusion of the observations.

4. *Origin of the epizootic.*

We were not able to obtain any evidence which would enable us to come to a conclusion as to the origin of the epizootic in Dhand.

It is practically certain that no person suffering from or incubating plague arrived in the village before the epizootic began. As regards the question of the introduction of plague by healthy persons, who had been exposed to infection elsewhere, we may say that although we made careful inquiries in all the houses in the neighbourhood of which the epizootic began, we failed to elicit any information pointing to the disease having been introduced in this way. It is true that at this time many of the villagers used to go to and fro between Dhand and Amritsar, which was infected, and it is impossible to exclude this mode of origin, more especially as a certain class of the villagers are not disposed to admit that they have visited friends or relatives ill with plague in other villages or towns.

On the other hand, we may exclude the possibility of introduction by migration of infected rats, as at this time, so far as could be ascertained, there was no infected village or town within five miles of Dhand. In this connection it is to be noted that a chronic plague rat was found on the 11th January, or only about a fortnight before the first acute plague rat was taken. We have, however, fully discussed elsewhere (vol. VII. p. 457) the question of the lighting up of chronic into acute plague and we need not enter into it here.

We must then leave the question of the origin of the epizootic unsettled.

5. *Severity and extent of the epizootic.*

The epizootic in Dhand was apparently of very moderate severity. The number of plague-infected rats found was only 34 as compared with 261 in Kasel. If we add to the latter figure 89 dead rats found in Kasel during the epizootic period, which were too putrid for diagnosis, the plague mortality among the rats in Kasel becomes ten times as great as in Dhand.

We must, however, point out that we have reasons for supposing that in Dhand a larger proportion of the dead rats found were concealed than in Kasel. But, after making full allowance for this possibility and for the difference in the size of the villages, there is no question that the Dhand epizootic fell far short of the Kasel epizootic in point of severity.

We think that this difference was probably mainly due to the relatively sparse rat population in Dhand at the time the epizootic broke out. A comparison of the number of rats taken per 100 traps set in the two villages during their respective epizootic periods (Tables Nos. IX and X) shows that the rat infestation of Dhand was relatively extremely low. The great diminution of the rat population in Dhand seems also to afford the best explanation of the termination of the epizootic at a time when fleas were prevalent and the temperature was favourable for the spread of the disease.

Apart from the limitation of the epizootic in Dhand, which was indicated by the small number of plague-infected rats found, it is interesting to note that the disease appeared to be of a less virulent type here than in Kasel. Thus, the number of live plague rats, most of which had the disease in a subacute form or appeared to be recovering from an acute attack, was 44 % of the total number of plague rats as compared with 13 % in Kasel.

V. Relation between the Epizootic and Epidemic.

The relation between the epizootic and epidemic can best be seen by a study of the maps appended and of Tables XIX and XX.

(1) *Relation in time.*

The relation in time becomes apparent by reference to Tables XIX and XX, which latter shows the number of infected rats and the number of plague attacks and deaths for each week of the period during which observations in Dhand were carried out.

TABLE XX.

Showing number of plague cases and plague-infected rats in Dhand week by week.

Week ending	Plague cases	Plague deaths	Rats			
			Acute plague	Too putrid for diagnosis	Chronic plague	Grand total
5/12/05	—	—	—	—	—	—
12/12/05	—	—	—	—	—	—
19/12/05	—	—	—	—	2	2
26/12/05	—	—	—	—	1	1
2/1/06	—	—	—	—	—	—
9/1/06	—	—	—	—	—	—
16/1/06	—	—	—	—	1	1
23/1/06	—	—	—	—	—	—
30/1/06	—	—	3	—	—	3
6/2/06	1	—	1	—	—	1
13/2/06	4	—	2	—	—	2
20/2/06	1	1	—	—	1	1
27/2/06	4	2	4	—	1	5
6/3/06	1	1	2	—	—	2
13/3/06	—	1	2	—	1	3
20/3/06	—	—	1	—	1	2
27/3/06	2	1	2	—	—	2
3/4/06	3	2	7	—	—	7
10/4/06	6	2	2	—	1	3
17/4/06	3	2	—	1	1	2
24/4/06	5	2	2	—	—	2
1/5/06	1	2	—	—	—	—
8/5/06	1	2	—	—	—	—
15/5/06	—	1	—	—	—	—
22/5/06	—	—	—	—	—	—
29/5/06	—	—	—	—	—	—
5/6/06	—	—	—	—	—	—
12/6/06	—	—	—	—	1	1
19/6/06	—	—	—	—	—	—
26/6/06	—	—	—	—	—	—
3/7/06	—	—	—	—	—	—
10/7/06	—	—	—	—	—	—
17/7/06	—	—	—	—	—	—
24/7/06	—	—	—	—	—	—
31/7/06	—	—	—	—	—	—
7/8/06	—	—	—	—	—	—
14/8/06	—	—	—	—	—	—
21/8/06	—	—	—	—	—	—
28/8/06	—	—	—	—	—	—
4/9/06	—	—	—	—	—	—
11/9/06	—	—	—	—	—	—
18/9/06	—	—	—	—	—	—
25/9/06	—	—	—	—	—	—
2/10/06	—	—	—	—	—	—
9/10/06	—	—	—	—	—	—
16/10/06	—	—	—	—	—	—
23/10/06	—	—	—	—	—	—
30/10/06	—	—	—	—	—	—
6/11/06	—	—	—	—	—	—
13/11/06	—	—	—	—	—	—
20/11/06	—	—	—	—	—	—
27/11/06	—	—	—	—	—	—

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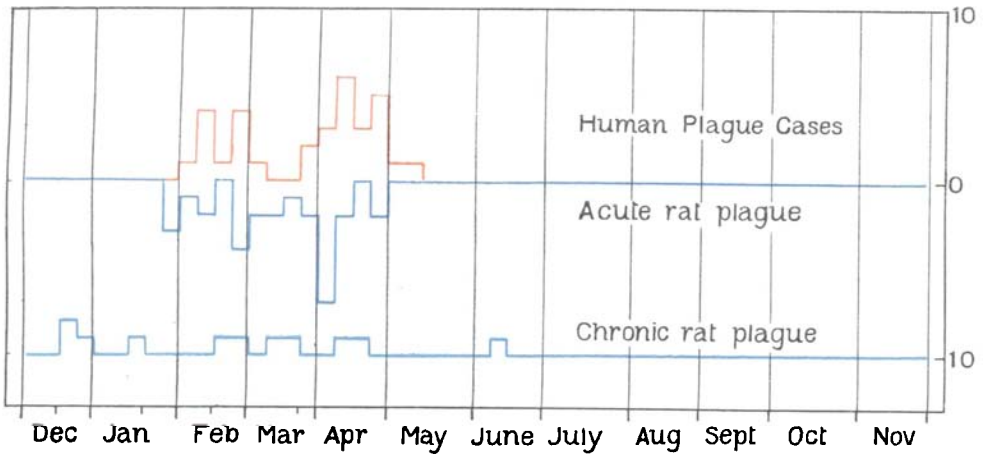

Human and rat plague in Dhand

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It will be seen from Table XIX that the first acute plague rat was taken on the 27th January and the last on the 21st April, while the first human case was attacked on 6th February and the last on 2nd May.

It is at once evident, then, that in Dhand, (1) rat plague preceded human plague, and (2) human plague ceased shortly after the cessation of plague among the rats.

2. *Relation in place.*

We propose only briefly to refer to different groups of cases.

Cases A, B, C and E lived in the neighbourhood of the place where the first plague-infected rats were found.

Case D is shown on Map 1 both at his residence and at the house where he was probably infected. He had removed a dead plague rat from the latter house four days prior to his attack.

Case F. Previous to attack no plague rat had been found in the vicinity of the residence of this case. The patient was a child, aged seven, whose movements prior to her illness could not be accurately ascertained.

Cases G, H and I lived in house No. 378. Cases *H* and *I* were attacked within a few hours of each other and two days after case *G* became ill. Thirteen days before case *G* was attacked a plague-infected rat was found in a lane not far from this house. The house was shown to be infective to guinea-pigs on the day following the attack of *G*.

Case J, who lived in another house, No. 340, was a frequent visitor to this infected house (No. 378) during the illness of *G*, *H* and *I*, being a near relative of the family. It will be seen from the map that previous to *J*'s attack there had been a case (*C*) in the house in which she resided (No. 340). The interval between the attacks, namely, a fortnight, and the fact that the house, No. 340, was not found infective to guinea-pigs three days after case *C*'s attack, suggest that case *J* got infected elsewhere.

Case K lived in a house immediately adjoining the infected house, No. 378.

Cases L and M. Plague-infected rats were found in the houses adjoining those in which both these cases lived.

Case N. No infected rats were found in or near the residence of this case, but guinea-pig experiments showed that the house contained infected rat fleas.

Case O. This was the first case that occurred in the "New village." No plague rats had been found in this portion of the village prior to *O*'s

attack, but three days afterwards a live infected rat (No. 22) was taken in a house not far from her residence. It will be seen from the Map (No. 1), that this house is a long way away from the old village, from which it is separated by the greater part of the new village. No plague-infected rats were found at any time in this intervening part of the new village. These facts do not favour the supposition that the epizootic spread by contiguity from the old to the new village. They seem, on the contrary, to suggest that infection, introduced by human agency, probably by case *O*, gave rise to an epizootic of plague among the rats in the neighbourhood. It was ascertained that case *O* used to go to the old village daily to get lessons in sewing, but we could not get any history of her having visited at a house which had been proved to be infected.

Case P. A plague-infected rat was found in the immediate vicinity of the residence of this case 18 days prior to his attack.

Cases Q[1], *T, and DD.* No plague-infected rats were found in or near the residences of these cases. The house which furnished cases *Q* and *T* was, however, proved to contain infected rat fleas, while the house occupied by *DD* was shown to be infective to a guinea-pig.

Cases R and W. Case R was attacked with plague on 5th April in another village (Chabal) and was brought to Dhand next day. *Case W*, who is a brother of case *R*, had lived with him in Chabal and had come to Dhand with him: he was attacked six days after leaving Chabal. Dead rats were found at the time case *R* became ill in the house in which these cases lived in Chabal. Case *R* was, therefore, undoubtedly an imported case. Case *W* may have been infected in Chabal, in which case his incubation period would have been at least six days: or, again, he may have been infected after his arrival in Dhand by means of fleas which had been brought from his infected house in Chabal. No plague rats were found in the immediate neighbourhood of the house they occupied in Dhand.

Cases U, V, X, Y, AA and BB all occurred in the new village, in association with plague among the rats in the neighbourhood.

Case Z. Plague rats had been found a fortnight previously in a store for chaff, which immediately adjoined the residence of this case.

Cases EE and FF occurred in adjoining houses. Plague-infected rats had been found ten days previously on both sides of their houses.

Analysing the 32 plague cases with reference to their association or

[1] Marked *R* in Map 1, in northernmost part of village.

otherwise with plague rats, we may divide them into the following two groups:—

Group I: comprising 22 cases, inhabiting 18 houses, in which or in the vicinity of which plague rats were found before or at the time of the occurrence of the cases. The cases included in this group are:—*A*, *B*, *C*, *D*, *E*, *G*, *H*, *I*, *J*, *K*, *L*, *M*, *P*, *U*, *V*, *X*, *Y*, *Z*, *AA*, *BB*, *EE* and *FF*.

Group II: comprising 10 cases, inhabiting 8 houses, in which or in the vicinity of which no plague rats were found before or at the time the cases were attacked. The cases in this group are *F*, *N*, *O*, *Q*, *R*, *S*, *T*, *W*, *CC* and *DD*. Three of these 8 houses, furnishing 4 cases, namely, *N*, *Q*[1] and *T*, and *DD*, were shown by guinea-pig experiments to contain infective rat fleas (Table XXI).

TABLE XXI.

Showing houses which furnished plague cases, but not plague rats, and in which the house was shown to be infective by guinea-pig experiments. The experiments are numbered consecutively in chronological order.

No.	House No.	Date on which guinea-pig was put in the house	Reference to case, and remarks
I	349	9/2/06	Case B: guinea-pig died of plague
II	378	23/2/06	Cases G, H and I: guinea-pig died of plague
III	39	31/3/06	Case N: two guinea-pigs died of plague and fleas from house infected a guinea-pig in the laboratory
IV	225	10/4/06	Cases Q and T: fleas from guinea-pig put down in house infected a guinea-pig in laboratory
V	220	25/4/06	Case DD: guinea-pig died of plague

Of the remaining 6 cases, 2, namely, *R* and *W*, were imported, and 2 others, namely, *S* and *CC*, lived in the neighbourhood of one of the houses shown to contain infected rat fleas. The remaining 2 cases, namely, *F* and *O*, were children whose movements before their illness could not be accurately determined. It may be mentioned, however, that plague rats were found in the vicinity of the houses of cases *F* and *O*, 10 days and 3 days, respectively, after they fell ill.

Summarising these observations on the place relation of the epidemic to the epizootic in Dhand, we may say that, while we were able to show that human plague occurred in association with rat plague in the near neighbourhood, we usually failed to establish a similar association in individual houses in which cases occurred. Our failure to trace this more intimate association between plague cases and plague rats must,

[1] Marked *R* in Map 1, in northernmost part of village.

we consider, have been largely due to the limitation of our methods of search for the latter, and perhaps to concealment on the part of the villagers who had not quite got accustomed to our presence at the time of the epidemic.

Finally, in attempting to estimate the closeness of the association between human plague and rat plague in a village such as Dhand we must take into account the small size and close aggregation of the houses and the free communication by means of rat burrows between neighbouring houses.

It will then be readily apparent that in Dhand the association which existed between plague cases and plague rats found in an adjoining house or even plague rats found in a house near by, but not immediately adjoining, may often have been more intimate than that which often obtains between human cases and plague rats found in different rooms or on different floors, of large premises, such as exist in cities.

It follows from what we have just said that in Dhand the appearance of plague rats in houses was not often followed by the occurrence of plague among the inmates.

Excluding 12 live plague-infected rats, we found in Dhand during the epizootic 22 dead plague rats. Of these, 14 were found in lanes, unoccupied houses or godowns, and hence not in close association with human beings. The remaining eight plague rats were found in six occupied houses, either in the actual living rooms, or in rooms directly communicating with them. These six houses contained 31 inmates. Two houses, containing seven occupants, were evacuated a week after the finding of plague rats in them and four of the 31 persons were inoculated—one two days after and three a week after plague rats were found in their houses. We may consider that all these persons were susceptible to plague infection but not a single one developed the disease.

APPENDIX.

Abstract of Plague Cases in Dhand.

Note:—A guinea-pig experiment consisted in allowing one or two guinea-pigs to run free for a night in the house in which a plague case occurred. The guinea-pigs were removed in the morning and the fleas caught on them were, in some instances, transferred to another guinea-pig in the laboratory. By a positive experiment is meant the death of either or both of these guinea-pigs from plague; by a negative experiment—that both remained healthy.

Case A.

Ruldoo, male, aet. 40, Hindu, water-carrier. Lives in house No. 352, Dhand; has not left the village for about 10 days. Attacked on 6th February—fever and left axillary bubo. Convalescent on 12th February:—bubo subsided without suppuration; material taken from the bubo on 9th February; films and cultures positive.

Rats—Live plague rats from adjoining house on 30th January.

Guinea-pig experiment—negative.

Connected previous case—nil.

Case B.

Mehr Singh, male, aet. 16, Hindu, dyer. Residence—No. 349, Dhand. Has not left the village for some months, except to go to Kasel occasionally. Attack—7th February—right axillary bubo and fever. Convalescent on 14th February; bubo subsided without suppuration. Material taken from the bubo on 9th February; films and cultures positive.

Rats—Live plague rats from adjoining houses, 347 and 350, on 27th January and 2nd February, and a dead plague rat from the latter house on 9th February. Four mummified rats from the back rooms of patient's house.

Guinea-pig experiment—positive.

Connected cases—nil.

Case C.

Khemi, female, aet. 26, Jat Sikh. Residence—340, Dhand. Arrived from another non-infected village 10 days previous to attack. Attack—12 February—left femoral bubo and fever. Convalescent on 23rd February; bubo subsided without suppuration.

Rats—A live plague rat from next house but one on 30th January. Patient was in the habit of going to this house.

Guinea-pig experiment—negative.

Connected cases—*vide* Cases E and L.

Case D.

Rhulla, male, aet. 30, Mahomedan, bhishti, employed as village watchman. Residence—498, Dhand. Attack—13th February—left femoral bubo and fever (104° F.). Died on 18th February. Material taken from the bubo on 17th February. Films and cultures positive.

Rats—A chronic plague rat from house No. 492 on 14th February; and a dead plague rat at No. 350 on 9th February, in which house patient assisted in the search for rats on that date.

Guinea-pig experiment—negative.

Connected cases—nil.

Case E.

Tejo, female, aet. 9, Jat Sikh. Residence—upper storey of No. 338, Dhand. Has not left the village for two months. Attack on 13th February—right cervical bubo and fever (103·6°). Convalescent on 23rd February; bubo subsided without suppuration.

Rats—Nearest plague rat from house No. 342 on 30th January.

Guinea-pig experiment—negative.

Connected cases—probably visited Case C on 13/2/06, the day of her (E's) attack.

Case F.

Santi, female, aet. 7, Jat Sikh. Residence—upper storey of No. 181, Dhand. Attack—16th February—double cervical buboes and fever (105·2° F.). Convalescent on 27th February. Bubo opened on 2nd March—pus sterile.

Rats—None in the vicinity till some weeks after the attack.

Guinea-pig experiment—negative.

Connected cases—nil.

Case G.

Hazara, male, aet. 8, Jat Sikh. Has not left the village. Residence—No. 378, Dhand. Attack—21st February—no bubo; fever 104° F.: died 22nd February.

Rats—A dead plague rat found in lane not far from this house on 9th February.

Guinea-pig experiment—positive.

Connected cases—H, I and J.

Case H.

Rami, female, aet. 70, Jat Sikh. Grandmother of Case G. Residence—No. 378, Dhand. Attack—24th February, fever 105·2° F., stated she had no bubo, but did not allow examination of inguinal regions. Died on 27th February at midnight.

Rats—vide Case G.

Guinea-pig experiment—positive.

Connected cases—G, I and J.

Case I.

Mangi, male, aet. 6, Jat Sikh. Residence—No. 378, Dhand, brother of Case G. Attack—24th February, fever 104·6° F.; developed a right inguinal bubo on 26th February. Died 27th February.

Rats—
Guinea-pig experiment } *vide* Case G.

Connected cases—H G and J.

Case J.

Nandi, female, aet. 70, Jat Sikh. Residence—No. 340, Dhand. Lives with Case C, who is her daughter-in-law. Frequently went to house No. 378 during the illness of Cases G, H and I, Case H being her sister, and attended the funeral party of the latter. Attack—night of 27th February, fever 103°; states she had no bubo, but did not allow examination—Fever continued and remained high and patient became delirious on 9th March and died on 12th March.

Rats—
Guinea-pig experiment } *vide* Case G.

Connected cases—G, H, and I. *Vide supra.*

Case K.

Taboo, male, aet. 10, Jat Sikh. Residence—upper storey of No. 335, Dhand. House adjoins No. 378, where Cases G, H, and I occurred. Attack—5th March, fever 103° F., and right inguinal bubo; convalescent on 13th March. Bubo opened on 15th March; culture from pus gave growth of *Staphylococcus*, no *B. pestis.*

Rats—Nearest plague-infected rat in lane near house No. 377 on 9th February, but house No. 378 proved by guinea-pig experiment to be infective on 24th February.

Guinea-pig experiment—negative.

Connected cases—nil.

Case L.

Waryam Singh, male, aet. 60, Jat Sikh. Residence—159, Dhand; has not left Dhand for some weeks, except to visit Mianpur village on 21st March. Attack—22nd March, fever; left inguinal bubo; vomiting and thickness of speech. Died on 23rd March at midnight.

Rats—A dead plague rat from neighbouring house, No. 60, on 18th March.

Guinea-pig experiment—negative.

Connected cases—Case L took medicine to Case C on a few occasions during the latter's illness.

Case M.

Imambibi, female, aet. 20, Mahomedan Teli. This woman came to Dhand from Bachiwind, a non-infected village in the Ajuala Tahsil on the 22nd March. After arrival in Dhand she lived with her brother in house No. 401 which had been closed prior to her arrival. Attack—26th March, left femoral bubo and fever. Died on 31st March.

Rats—A dead plague-infected rat was found in the room adjoining living room on 29th March.

Guinea-pig experiment—positive.

Connected cases—nil.

Case N.

Umri, female, aet. 40, Mahomedan Teli. Residence—39, Dhand. Attacked on 28th March, died 29th March. This case was not seen till after death, when no bubo was found on examination. She is said to have had fever and delirium with blood-tinged expectoration.

Rats—None in vicinity.

Guinea-pig experiment—positive.

Connected cases—nil.

Case O.

Tabo, female, aet. 10, Jat Sikh. Residence—603, Dhand (in new village). This girl had returned from a visit to her uncle in Chhina village in the Ajuala Tahsil about the 16th March. There is no evidence that Chhina was infected. She frequently went to house 429, Dhand where she took sewing lessons and is said to have swept out that house on 27th March. Attack—29th March, fever and left femoral bubo; convalescent on 7th April; bubo subsided without suppuration.

Rats—None at or near her residence prior to attack, but plague rats at houses Nos. 583 and 618 in the vicinity on 1st April and 6th April.

Guinea-pig experiment—none at residence; negative in house No. 429.

Connected cases—nil.

Case P.

Isar Singh, male, aet. 45, Jat Sikh. Residence—456, Dhand. Came to this house about 15 days before attack from a non-infected part of the village. Attack—31st March; fever on 1st April; a painful swelling developed below outer half of right clavicle, which later became hard with oedema of overlying skin. Died on 4th April. Material taken from the swelling on 3rd April—smear indefinite; culture positive.

Rats—A dead plague rat in lane adjoining residence on 13th March.

Connected cases—nil.

Case Q[1].

Rukki, female, aet. 25, Chuhra (sweeper). Residence—225, Dhand. Attack—4th April; fever and right femoral bubo; marked slurring of speech; convalescent on 13th April; bubo subsided without suppuration.

Rats—None in house or vicinity.

Guinea-pig experiment—*vide* Case T.

Connected cases—Case T.

Case R.

Abdul Rahman, male, aet. 9, Mahomedan Kamboh. Brought to house No. 85, Dhand on the morning of 6th April suffering from plague. Attacked during night of 5th April in Chabal village—right femoral bubo and fever; convalescent on 13th April; bubo subsided without suppuration.

Rats—History of dead rats at residence in Chabal; none in or near residence at Dhand.

Connected cases—Case W.

Case S.

Dhunda, male, aet. 5, Mahomedan Teli. Residence—3, Dhand. Patient is said to have gone to house No. 39 (*vide* under Case N) frequently prior to attack. Attack—7th April; fever and right inguinal bubo. Died on 13th April.

Rats—Live infected rats from houses 185 and 186 prior to attack.

Guinea-pig experiment—negative.

Connected cases—nil.

Case T.

Santi, female, aet. 12, Chuhra. Residence—225, Dhand with Case Q. Attack—fever on 7th and left axillary bubo on 8th April. Died on 11th April.

Rats—None in house or vicinity.

Guinea-pig experiment—positive on 10/4/06.

Connected cases—Q attacked in same house on 4th April.

Case U.

Asso, female, aet. 16, Hindu, water-carrier. Residence—622, Dhand. Attack on 10th April, fever 103·8° F. and left axillary bubo. Convalescent on 13th April; bubo subsided without suppuration.

Rats—Dead plague rats from house No. 618, in adjoining courtyard, on 6th April.

Guinea-pig experiment—negative.

Case V.

Bhagat Singh, male, aet. 20, Hindu, water-carrier, employed in a native regiment at Bannu. Came to his home on leave on 15th March. Residence—622, Dhand, with his sister Asso (Case U). Attack—10th April; fever and left femoral bubo the next morning. Unconscious on 11th and 12th. Died on the evening of 12th April.

Rats—vide Case U.

Guinea-pig experiment—*vide* Case U.

Connected case—Case U.

[1] Marked *R* in Map 1, in northernmost part of village.

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Case W.

Abdul Gani, male, aet. 6, Mahomedan Kamboh. Came from Chabal on 6th April to stay in house No. 85, Dhand, where his brother, Case R, had been brought on the 5th April suffering from plague. Attack—fever on 12th April; temperature 102° F. on 13th and 14th, with intermission on the 15th and 16th when patient appeared well. On the 17th he developed femoral buboes on both sides and a swelling behind the angle of right jaw and slight fever (99° F. to 100° F.). Convalescent on 21st—all the buboes subsided without suppuration.

Rats—vide Case R.

Guinea-pig experiment—*vide* Case R.

Connected case—Case R. *Vide supra.*

Case X.

Gogi, male, aet. 20, Mahomedan, water-carrier. Residence—587, Dhand. Attack—fever on 14th April; on 17th temperature 102·2° F. with a small left inguinal bubo. Convalescent on 21st April; bubo subsided without suppuration.

Rats—Plague rats from houses Nos. 583 and 618 in vicinity on 1st April and 6th April.

Guinea-pig experiment—negative.

Connected cases—nil.

Case Y.

Jugo, female, aet. 30, Hindu, water-carrier. Residence—589, Dhand. Patient went to see Cases U and V in house No. 622 on 11th April and attended the latter's funeral party on 13th April. Attack—right axillary bubo and fever on 14th April—convalescent on 17th; bubo subsided without suppuration.

Rats—Plague rats. *Vide* under Case X.

Guinea-pig experiment—negative.

Connected cases—U and V. *Vide supra.*

Case Z.

Parsino, female, aet. 12, Jat Sikh. Residence—122, Dhand. This girl left Dhand on or about the 11th April to stay with a relative in Modhe, a village in the Tarn Taran Tahsil. Attack—about 16th April in Modhe, with fever. Patient was brought back by her father to Dhand on the 20th and died on the 21st April. The case was not seen till after death and examination for buboes was not permitted, but relatives said that patient had a small right femoral bubo when brought back to Dhand. No plague was reported from Modhe till 30th April when some cases occurred at a distance from the quarter where patient stayed.

Rats—No history of dead rats in or near the house in Modhe where patient stayed. Infected rats from house No. 137, Dhand, which immediately adjoins No. 122, on 31st March and 3rd April.

Connected cases—nil.

Case AA.

Bibi, female, aet. 20, Mahomedan Kamboh. Residence—583, Dhand. Attack—19th April, right femoral bubo and fever. Died on 22nd April.

Rats—Live plague rat from residence on 1st April and a dead plague rat from adjoining house on 6th April.

Guinea-pig experiment—positive.

Connected cases—nil.

Case BB.

Luchmi, female, aet. 25, Hindu, water-carrier. Residence—588, Dhand. Attack—20th April, fever followed by left femoral bubo. Died on 26th April.

Rats—vide Case AA.

Guinea-pig experiment—negative.

Connected cases—nil.

Case CC.

Bhega, female, aet. 30, Mahomedan Teli. Residence—No. 2, Dhand. Attack—21st April; fever, no bubo found, but complete examination not allowed. Blood-tinged expectoration on 24th. Patient died on 25th April.

Rats—None in house or vicinity.

Guinea-pig experiment—(on 25th April) negative.

Connected cases—nil.

Case DD.

Jawali, female, aet. 7, Chuhra. Residence—220, Dhand. Attack—fever on 23rd April, temperature on 24th 102·6° F.; got double inguinal buboes on 28th and a right axillary and double submaxillary buboes on 29th. Fever continued and patient died on 13th May.

Rats—None in house or vicinity.

Guinea-pig experiment—positive.

Connected cases—nil.

Case EE.

Jhando, female, aet. 21, Mahomedan, bhishti. Residence—386, Dhand. Attack—1st May; fever 102·2° F.; died 4th May. Examination for buboes not permitted and relatives said there were none present.

Rats—Plague rats from house adjoining and lane adjoining on 21st April.

Guinea-pig experiment—negative.

Connected cases—nil.

Case FF.

Sultano, female, aet. 22, Mahomedan, bhishti. Residence—387, Dhand. Attack—2nd May; fever and delirium. No examination for buboes permitted. Died 4th May.

Rats—vide under Case EE.

Guinea-pig experiment—negative.

Connected cases—nil.

IV. OBSERVATIONS WHICH HAVE SPECIAL REFERENCE TO THE VILLAGE OF KASEL.

I. Introduction.
  (1) Situation, etc.
  (2) Census results.
II. Previous epidemics of plague.
III. The plague epidemic of 1906.
  (1) Period before the epidemic.
  (2) Period during the epidemic.
    (*a*) Severity and duration of epidemic.
    (*b*) Clinical features of the cases.
      1. Type of the cases.
      2. Situation of the bubo.
      3. Mode of onset.
      4. Sex incidence.
      5. Age incidence.
      6. Caste incidence.
      7. Case mortality.
    (*c*) Distribution of the cases amongst the houses.
    (*d*) Contact with previous cases.
IV. The epizootic.
  (1) Period before the epizootic.
  (2) Period during the epizootic.
  (3) Period after the epizootic.
  (4) Origin of the epizootic.
V. Relation between the epizootic and the epidemic.
  (1) Relation in time.
  (2) Relation in place.
  (3) Interval between the finding of dead plague rats in houses and the occurrence of the first plague case in them.
  (4) Finding of plague-infected rats in houses not always followed by plague cases.
  (5) The influence of evacuation of houses, in which dead plague rats were found, on the incidence of plague on the occupants.

I. Introduction.

1. *Situation.*

Kasel is situated about three-quarters of a mile south-west of Dhand and hence is at a distance of about nine miles from Amritsar city. It has communication by cart roads with Amritsar, Tarn Taran, Ghandwind, Dhand and several other villages. Unlike Dhand, part of the area on which Kasel is situated is raised considerably above the surrounding country. This is due to the present village having been built on the

ruins of previous villages. The highest point corresponds to houses 235, 236 near the middle of the village. From this point the ground slopes down in all directions. The peripheral parts of the village are built on level ground. The area of Kasel is roughly 40 acres.

2. *Census results.*

The population, according to our census, was 3938, and the density of population roughly 100 per acre.

The number of occupied houses is 806. 320 of these contain a single room, 276 two rooms, and 210 more than two rooms. 77 of the houses are two-storied, the upper storey usually consisting of a single room. Of the occupied houses only 25 are brick and mortar structures, the remainder being mud houses of the type already described.

The inhabitants are of the same castes as those of Dhand and follow similar occupations. Adopting the same classification as was done in the latter village, we find that the population is made up of:

Sikhs and Hindus	1419
Mahomedans	2063
Chuhras	456

It will be noticed that the Sikhs and Hindus bear a smaller proportion to the total population than in Dhand.

II. Previous Epidemics of Plague.

Plague first appeared in Kasel in October 1902, the first case recorded being a sweeper, who apparently contracted the disease in another village and died in Kasel on 13th October 1902. The epidemic which followed lasted till the second week of January 1903. There were 487 attacks with 225 deaths.

With the exception of a few imported cases the village remained free from plague until the last week in December 1903, when the disease again appeared as an epidemic. This second epidemic lasted till the end of April 1904. The number of attacks was 386 and of deaths 273. After another plague-free interval of nine months, the disease reappeared early in February 1905. The epidemic of 1905 lasted till the end of April and consisted of 342 attacks with 210 deaths. The last recorded death from plague in 1905 occurred on the 28th of April. We could not determine the source of origin of the epidemics of 1904 and 1905.

In Kasel, as in Dhand, all the evidence went to show that during the three epidemics dead rats were found in connection with plague cases.

III. The Plague Epidemic of 1906.

1. *Period before the epidemic.*

The last death from plague in 1905 occurred on the 28th April. From the end of November, when the Commission commenced its observations in the village, till the 12th March, no case of plague came to light. On the latter date a child of the Chuhra caste, who had left Kasel about twelve days previously, was brought back to the village suffering from plague and died on the 14th March (*vide* Case 1, Appendix). No further case occurred till the 5th April.

2. *Period of the epidemic.*

(*a*) *Severity and duration of epidemic.*

The epidemic of 1906 consisted of 75 cases. The date of attack of the first case was the 5th April and of the last case the 6th July. A list of the cases and a short description of each will be found in the Appendix.

(*b*) *Clinical features of the cases.*

1. *Type of the cases.* Of 71 cases, in which a complete examination was made, 68 were bubonic, the other three having no buboes. One of the three latter cases (No. 11) had primary plague pneumonia. Among the 68 bubonic cases were two with recent abrasions (Nos. 5 and 8), and two with carbuncles (Nos. 33 and 65), in the drainage area of the affected glands. One bubonic case (No. 13) developed a secondary plague pneumonia. Four cases, viz. Nos. 6, 31, 53 and 67, were not completely examined, so that the presence of a bubo could not be excluded. Of these, No. 6 was not seen till just before death, but from the history it is probable that it was a case of plague pneumonia: case No. 31 had a phlyctenule on the right ankle and case 67 had cough and rusty sputum in which abundant *B. pestis* were present.

2. *Situation of the bubo.* The situation of the bubo in the 68 bubonic cases examined was as follows.

Femoral	52
Axillary	8
Cervical	4
Femoral and Cervical	3
Axillary and Cervical	1

3. *Mode of onset.* In 54 cases pain in the gland, with or without swelling, was amongst the earliest symptoms. In seven cases the bubo developed on the day following the appearance of other symptoms; in four cases after two days, in two cases after three days and in one case after eight days.

4. *Sex incidence.* Table XXII shows the relative proportion of males and females attacked. It will be seen that the incidence on females was more than twice as high as that on males.

TABLE XXII.

Showing the incidence of attacks on males and females in Kasel.

Sex	Total population	Plague attacks	Incidence per 1000
Males	2129	25	12
Females	1809	50	28

TABLE XXIII.

Showing the relative incidence of attacks on persons at different age periods in Kasel.

Age period	Total population	Plague attacks	Incidence per 1000
0—5 years	836	5	6
6—10 ,,	477	14	29
11—20 ,,	860	14	16
21—40 ,,	1144	33	29
Over 41 ,,	621	9	14

5. *Age incidence.* Table XXIII shows the relative incidence on persons at different age periods. It will be seen that the very young were apparently less liable to attack than persons of other ages.

6. *Caste incidence.* The plague incidence on the three classes into which we have grouped the inhabitants is summarised in Table XXIV. This table shows that in Kasel the sweepers, who represent the lowest classes of the village community, suffered more than the Hindus or Mahomedans. In Dhand, it will be remembered, the incidence was greatest on the Hindus.

TABLE XXIV.

Showing the plague incidence on different castes in Kasel.

Caste	Total population	Plague attacks	Incidence per 1000
Sikhs and Hindus	1419	26	18
Mahomedans	2063	32	15
Chuhras (menials)	456	17	37

7. *Case mortality.* Out of 75 cases, 41 or almost 55 % ended fatally. The longest interval between attack and death was 10 days and the shortest one day. The average for 38 fatal cases in which the interval was accurately determined was a little over four days.

(*c*) *Distribution of cases among houses.*

The 75 cases inhabited 67 houses. One house furnished three cases, six houses furnished two cases each and 60 houses a single case each. All the cases were treated in their own homes during the whole period of their illness.

In the houses which furnished single cases the number of contacts was 273, of whom only 18 had been inoculated against plague. In other words out of 255 presumably susceptible persons who came into close contact with plague cases none were attacked.

(*d*) *Contact with previous cases.*

Out of 75 cases it was ascertained that 53 or 70 % did not, prior to attack, come into contact with other plague cases (*vide* Appendix, cases 2 to 4, 7, 10, 12 to 15, 17, 19, 20, 22 to 31, 34 to 37, 42 to 55, 58 to 61, 63, 65, 66, 68 and 70 to 75). Eleven cases (15 %) were found to have had contact with previous cases prior to becoming ill (Appendix, cases 9, 11, 16, 32, 33, 39, 41, 43, 57, 64 and 69). With regard to the remaining 11 cases (15 %) (Appendix, cases 1, 5, 6, 8, 18, 21, 38, 40, 56, 62 and 67), we could not determine whether or not such contact had taken place.

We may, however, conclude that the majority of cases cannot have received their infection from a previous case.

IV. The Epizootic.

1. *Period before the epizootic.*

(From 29th November, 1905, to 1st April, 1906.)

(Map 2.)

During this period 2510 *Mus rattus* were examined at the laboratory; 2460 of these had been trapped, and 50 were found dead. It is to be noted that trapping was suspended in Kasel from 1st January, 1906, to 20th February. None of the rats examined were found to be suffering from acute plague, but two live rats were found with chronic abscesses in the spleen from which *B. pestis* was recovered. The first of these chronic plague rats was trapped on 9th December and the last on 12th December (*vide* Map 2).

2. *Period of epizootic.*

(From 2nd April, 1906, to 17th July, 1906.)

(Maps 1 and 3—16. Table XXV.)

During this period 1254 rats were examined, of which number 911 were caught alive and 343 were found dead. Plague was identified in 27 live rats and in 226 dead rats. 89 of the dead rats were found in such an advanced stage of putridity that a diagnosis could not be made. Many of these were found in houses in association with proved plague rats and there can be little doubt that most of them died of plague.

The first acute plague rat was found in a dying condition in house No. 122 on the 2nd April (*vide* Map No. 1, Serial No. 1 and Table No. 24). The occupants informed us that about five days previously they had noticed a bad smell in the house which they attributed to a dead rat. The next two plague rats were found dead in house No. 114 which is in the vicinity of No. 122 (*vide* Map No. 1, Serial No. 2 and Table No. 24). These first three plague rats exhibited, on post-mortem examination, buboes and other lesions typical of acute plague and, microscopically, abundant *B. pestis* were present in the buboes and heart-blood.

The further progress of the epizootic can best be followed by referring to Map 1 and Table XXV and the series of weekly Maps Nos. 3—16.

The latter series shows well the gradual extension of the epizootic outwards from the original focus of infection, in the same rather irregular manner as was noted in the case of Dhand. It will be noticed, however, that this extension was not associated with the simultaneous disappearance of the epizootic from the more central parts. On the contrary infected rats continued to be found in the vicinity of the original focus of infection till the sixth week of the epizootic period, by which time the epizootic had spread over a large part of the village.

3. *Period after the epizootic.*

(18th July—5th December, 1906.)

The last acute plague rat was found on the 17th July, 1906. From the 18th July to the conclusion of the observations in Kasel on the 5th December, 1906, 1468 rats were examined, of which 1449 were trapped alive and 19 were found dead. While no rat with acute plague was found during this period seven rats suffering from chronic plague

MAP 1

KASEL VILLAGE

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MAP 1

KASEL VILLAGE

100 *feet*

- Human plague case (serial number)
- Plague infected rat or rats (serial number)
- Putrid or mummified rat or rats

TANK

ROAD TO DHAND

SHIVALA

TAKEH

ROAD TO MIAN PUR

MOSQUE

ROAD TO GANDIVIND

ROAD TO BHAKNAH

ROAD TO GANDIVIND & SI KHAN

DHURMSALA

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MAP 2

KASEL VILLAGE

Period before the epizootic,
29 Nov. 1905 to 1 April, 1906

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MAP 2

KASEL VILLAGE

Period before the epizootic,
29 Nov. 1905 to 1 April, 1906

100 *feet*

- Human plague case (imported)
- Chronic plague rats (date)

TANK

ROAD TO DHAND

SHIVALA

TAKEH

ROAD TO MIAN PUR

MOSQUE

ROAD TO GANDIVIND

ROAD TO BHAKNAH

ROAD TO GANDIVIND & SI KHAN

DHURMSALA

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MAP 3

KASEL VILLAGE

First week of epizootic,
2 April, 1906 to 8 April, 1906

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MAP 3

KASEL VILLAGE

First week of epizootic,
2 April, 1906 to 8 April, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)

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MAP 4

KASEL VILLAGE

Second week of epizootic,
9 April, 1906 to 15 April, 1906

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MAP 4

KASEL VILLAGE

Second week of epizootic,
9 April, 1906 to 15 April, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)
- Putrid or mummified rat

TANK

ROAD TO DHAND

SHIVALA

TAKEH

ROAD TO MIAN PUR

MOSQUE

ROAD TO BHAKNAH

ROAD TO GANDIVIND

ROAD TO GANDIVIND & SI KHAN

DHURMSALA

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MAP 5

KASEL VILLAGE

Third week of epizootic,
16 April, 1906 to 22 April, 1906

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MAP 5

KASEL VILLAGE

Third week of epizootic,
16 April, 1906 to 22 April, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)
- Putrid or mummified rat

TANK
ROAD TO DHAND
SHIVALA
TAKEH
ROAD TO MIAN PUR
MOSQUE
ROAD TO BHAKNAH
ROAD TO GANDIVIND
ROAD TO GANDIVIND & SI KHAN
DHURMSALA

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MAP 6

KASEL VILLAGE

Fourth week of epizootic,
23 April, 1906 to 29 April, 1906

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MAP 6

KASEL VILLAGE

Fourth week of epizootic,
23 April, 1906 to 29 April, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)
- Putrid or mummified rat

TANK
ROAD TO DHAND
SHIVALA
TAKEH
ROAD TO MIAN PUR
MOSQUE
ROAD TO BHAKNAH
ROAD TO GANDIVIND
ROAD TO GANDIVIND & SI KHAN
DHURMSALA

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MAP 7

KASEL VILLAGE

Fifth week of epizootic,
30 April, 1906 to 6 May, 1906

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MAP 7

KASEL VILLAGE

Fifth week of epizootic,
30 April, 1906 to 6 May, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)
- Putrid or mummified rat

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MAP 8

KASEL VILLAGE

Sixth week of epizootic,
7 May, 1906 to 13 May, 1906

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MAP 8

KASEL VILLAGE

Sixth week of epizootic,
7 May, 1906 to 13 May, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)
- Putrid or mummified rat

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MAP 9

KASEL VILLAGE

Seventh week of epizootic,
14 May, 1906 to 20 May, 1906

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MAP 9

KASEL VILLAGE

Seventh week of epizootic,
14 May, 1906 to 20 May, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)
- Putrid or mummified rat

TANK

ROAD TO DHAND

SHIVALA

TAKEH

ROAD TO MIAN PUR

MOSQUE

ROAD TO BHAKNAH

ROAD TO GANDIVIND

ROAD TO GANDIVIND & SI KHAN

DHURMSALA

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MAP 10

KASEL VILLAGE

Eighth week of epizootic,
21 May, 1906 to 27 May, 1906

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MAP 10

KASEL VILLAGE

Eighth week of epizootic,
21 May, 1906 to 27 May, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)
- Putrid or mummified rat

TANK

ROAD TO DHAND

SHIVALA

TAKEH

ROAD TO MIAN PUR

MOSQUE

ROAD TO BHAKNAH

ROAD TO GANDIVIND

ROAD TO GANDIVIND & SI KHAN

DHURMSALA

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MAP 11

KASEL VILLAGE

Ninth week of epizootic,
28 May, 1906 to 3 June, 1906

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MAP 11

KASEL VILLAGE

Ninth week of epizootic,
28 May, 1906 to 3 June, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)
- Putrid or mummified rat

TANK
ROAD TO DHAND
SHIVALA
TAKEH
ROAD TO MIAN PUR
MOSQUE
ROAD TO BHAKNAH
ROAD TO GANDIVIND
ROAD TO GANDIVIND & SI KHAN
DHURMSALA

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MAP 12

KASEL VILLAGE

Tenth week of epizootic,
4 June, 1906 to 10 June, 1906

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MAP 12

KASEL VILLAGE

Tenth week of epizootic,
4 June, 1906 to 10 June, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)
- Putrid or mummified rat

TANK

ROAD TO DHAND

SHIVALA

TAKEH

ROAD TO MIAN PUR

MOSQUE

ROAD TO BHAKNAH

ROAD TO GANDIVIND

ROAD TO GANDIVIND & SI KHAN

DHURMSALA

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MAP 13

KASEL VILLAGE

Eleventh week of epizootic,
11 June, 1906 to 17 June, 1906

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MAP 13

KASEL VILLAGE

Eleventh week of epizootic,
11 June, 1906 to 17 June, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)
- Putrid or mummified rat

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MAP 14

KASEL VILLAGE

Twelfth week of epizootic,
18 June, 1906 to 24 June, 1906

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MAP 14

KASEL VILLAGE

Twelfth week of epizootic,
18 June, 1906 to 24 June, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)

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MAP 15

KASEL VILLAGE

Thirteenth week of epizootic,
25 June, 1906 to 1 July, 1906

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MAP 15

KASEL VILLAGE

Thirteenth week of epizootic,
25 June, 1906 to 1 July, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)

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MAP 16

KASEL VILLAGE

Fourteenth and fifteenth weeks of
epizootic, 2 July, 1906 to 17 July, 1906

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MAP 16

KASEL VILLAGE

Fourteenth and fifteenth weeks of epizootic, 2 July, 1906 to 17 July, 1906

100 *feet*

- Human plague case (date of attack)
- Plague infected rat (date)

TANK

ROAD TO DHAND

SHIVALA

TAKEH

ROAD TO MIAN PUR

MOSQUE

ROAD TO BHAKNAH

ROAD TO GANDIVIND

ROAD TO GANDIVIND & Sl KHAN

DHURMSALA

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MAP 17

KASEL VILLAGE

Period after the epizootic,
18 July, 1906 to 5 Dec. 1906

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MAP 17

KASEL VILLAGE

Period after the epizootic,
18 July, 1906 to 5 Dec. 1906

100 *feet*

● Chronic plague rat (date)

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were trapped, the first on the 23rd August and the last on the 5th December (*vide* Map 17). It will be noticed that all these chronic plague rats were taken in houses in which or in the neighbourhood of which acute plague rats had been found during the epizootic period.

4. *Origin of the epizootic.*

In Kasel, as in Dhand, we were unable to come to a definite conclusion regarding the origin of the epizootic. At the time the epizootic began in Kasel several of the neighbouring villages, including Dhand, were infected. There was thus ample opportunity for the infection being brought in.

We have seen that the only imported case of plague, previous to the epizootic period, arrived in Kasel on the 12th March and died on the 14th (Appendix, Case 1). There are several reasons, however, for thinking that the disease among the rats did not originate from infection introduced by this case. Briefly stated these are as follows:

1. Guinea-pig experiments carried out on the 15th March in house No. 746 (the residence of Case No. 1), to determine whether the house was infective, gave negative results.

2. House No. 746 and all the houses in its vicinity were trapped on the 26th March and about 50 rats were taken. None of these rats was found to be plague-infected.

3. A reference to Map 1 will show that the houses where the first plague rats were found are at a considerable distance from house No. 746, and that no plague-infected rats were found in the immediate neighbourhood of the latter house, until several weeks after the epizootic had begun.

Having failed to satisfactorily connect the origin of the epizootic with the only imported case of plague, we made careful inquiries in all the houses in the neighbourhood where the first plague rats were found, in order to determine whether any healthy person who had been exposed to infection elsewhere had recently arrived there. The only facts that came to light suggesting that infection may have been introduced in this way were those in connection with the occupants of house No. 122, in which the first plague-infected rat was found on the 2nd April. House No. 122 is a goldsmith's shop, kept by two brothers who lived in house No. 177 Dhand. These men worked by day in their shop in Kasel, returning to Dhand at night. On the 6th of March a plague-infected rat had been found in the house occupied by their uncle, the next house to No. 177 Dhand. Subsequently a few plague rats were found in

TABLE XXV.

Showing the places at which, and the first and last dates on which, plague-infected, putrid or mummified rats were taken. The entries are consecutively numbered in accordance with the dates on which the first rat was taken or found. References to the human cases are inserted in the series in their order.

Serial No.	House No.	Plague-infected rats			Mummified or putrid rats		
		First	Last	Total	First	Last	Total
		Case 1. Imported 12/3/06. House 746.					
1	122	2/4/06	—	1	29/4/06	31/5/06	2
2	114	3/4/06	4/4/06	2	10/4/06	—	1
		Case 2. Attacked 5/4/06. House 68					
3	119	6/4/06	9/4/06	2	—	—	—
4	121	6/4/06	—	1	—	—	—
5	896	7/4/06	—	1	—	—	—
6	894	11/4/06	—	1	—	—	—
7	36	13/4/06	—	1	—	—	—
8	842	14/4/06	—	1	—	—	—
9	902	14/4/06	18/4/06	2	—	—	—
10	961	15/4/06	—	1	—	—	—
		Case 3. Attacked 15/4/06. House No. 1010					
11	249	16/4/06	—	1	—	—	—
12	82	17/4/06	1/5/06	3	—	—	—
13	50	17/4/06	—	1	—	—	—
14	55	17/4/06	—	1	—	—	—
15	376	16/5/06	18/5/06	4	17/4/06	—	1
16	869	17/4/06	—	1	—	—	—
		Case 4. Attacked 17/4/06. House No. 894					
17	111	18/4/06	19/4/06	2	—	—	—
18	118	18/4/06	—	1	—	—	—
		Case 5. Attacked 18/4/06. House No. 1158 Case 6. Imported 18/4/06. House No. 828					
19	843	19/4/06	22/4/06	2	—	—	—
20	112	19/4/06	—	1	—	—	—
21	784	19/4/06	20/4/06	2	—	—	—
22	960	19/4/06	23/4/06	2	—	—	—
23	248	20/4/06	24/4/06	2	12/5/06	—	1
		Case 7. Attacked 20/4/06. House 902					
24	113	—	—	—	21/4/06	—	1
25	782	21/4/06	29/4/06	2	28/4/06	—	1
26	881	22/4/06	27/4/06	2	—	—	—
27	779	22/4/06	26/4/06	3	—	—	—
28	969	23/4/06	—	1	—	—	—
29	833	—	—	—	24/4/06	—	1
30	12	24/4/06	—	1	—	—	—

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Serial No.	House No.	Plague-infected rats: First	Last	Total	Mummified or putrid rats: First	Last	Total
		Case 8. Attacked 24/4/06. House 901					
31	345	25/4/06	—	1	—	—	—
32	883	25/4/06	—	1	—	—	—
33	769	25/4/06	1/5/06	3	—	—	—
34	815	25/4/06	—	1	—	—	—
		Case 9. Attacked 25/4/06. House 901					
		Case 10. Attacked 25/4/06. House 897					
35	781	26/4/06	—	1	—	—	—
36	104	26/4/06	—	1	—	—	—
37	43	27/4/06	27/4/06	2	—	—	—
38	343	27/4/06	—	1	—	—	—
39	390	27/4/06	2/5/06	6	—	—	—
		Case 11. Attacked 27/4/06. House 857					
40	837	—	—	—	28/4/06	—	1
41	135	—	—	—	28/4/06	—	1
		Case 12. Attacked 28/4/06. House 246					
		Case 13. Attacked 28/4/06. House 838					
42	268	29/4/06	—	1	—	—	—
43	827	—	—	—	29/4/06	29/4/06	2
44	96	29/4/06	—	1	—	—	—
45	391	29/4/06	2/5/06	4	—	—	—
46	911	29/4/06	—	1	—	—	—
47	853	29/4/06	—	1	—	—	—
48	823	30/4/06	3/5/06	2	—	—	—
49	97	—	—	—	30/4/06	—	1
		Case 14. Attacked 30/4/06. House No. 868					
50	344	1/5/06	—	1	7/5/06	—	1
51	99	1/5/06	—	1	—	—	—
52	806	1/5/06	—	1	1/5/06	—	1
53	795	2/5/06	—	1	—	—	—
54	250	2/5/06	—	1	—	—	—
55	393	2/5/06	—	1	3/5/06	10/5/06	2
56	266	2/5/06	—	1	—	—	—
57	807	2/5/06	3/5/06	2	—	—	—
58	1013	2/5/06	—	1	—	—	—
		Case 15. Attacked 2/5/06. House No. 82					
59	253 (Lane)	3/5/06	—	1	—	—	—
60	389	3/5/06	—	1	—	—	—
61	918	—	—	—	3/5/06	4/6/06	2
		Case 16. Attacked 3/5/06. House No. 81					
62	51	4/5/06	7/5/06	6	6/5/06	8/5/06	3
63	757	4/5/06	8/5/06	2	—	—	—
64	759	—	—	—	4/5/06	—	1

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Serial No.	House No.	Plague-infected rats: First	Last	Total	Mummified or putrid rats: First	Last	Total
		Case 17. Attacked 4/5/06. House No. 1243					
65	424	5/5/06	—	1	—	—	—
66	255	5/5/06	9/5/06	5	6/5/06	12/5/06	5
67	1257	5/5/06	—	1	—	—	—
68	392	5/5/06	7/5/06	3	—	—	—
69	953	5/5/06	—	1	—	—	—
70	421	8/5/06	—	1	5/5/06	—	1
71	726	5/5/06	—	1	—	—	—
72	422	5/5/06	7/5/06	5	8/5/06	—	1
		Case 18. Attacked 5/5/06. House No. 83					
73	339	6/5/06	—	1	—	—	—
74	259 (Lane)	—	—	—	6/5/06	6/5/06	2
75	218	6/5/06	—	1	—	—	—
76	340	—	—	—	6/5/06	—	1
77	776	—	—	—	6/5/06	—	1
78	411	—	—	—	7/5/06	11/5/06	2
79	233	7/5/06	—	1	—	—	—
80	101	—	—	—	7/5/06	—	1
81	763	7/5/06	—	1	—	—	—
82	93	—	—	—	7/5/06	—	1
83	32	7/5/06	—	1	—	—	—
84	796	7/5/06	—	1	—	—	—
85	790	7/5/06	9/5/06	2	—	—	—
		Case 19. Attacked 7/5/06. House No. 775 Case 20. Attacked 7/5/06. House No. 43					
86	758	7/5/06	—	1	—	—	—
87	935	8/5/06	—	1	—	—	—
88	980	8/5/06	12/5/06	3	11/5/06	—	1
89	41	8/5/06	—	1	—	—	—
90	760	—	—	—	8/5/06	—	1
91	259	—	—	—	8/5/06	25/5/06	2
92	63	—	—	—	8/5/06	—	1
93	745	8/5/06	28/5/06	5	21/5/06	—	1
94	102	8/5/06	—	1	9/5/06	9/5/06	2
95	981	8/5/06	11/5/06	3	9/5/06	—	1
		Case 21. Attacked 8/5/06. House No. 902 Case 22. Attacked 8/5/06. House No. 78 Case 23. Attacked 8/5/06. House No. 756					
96	87	—	—	—	9/5/06	—	1
97	923	9/5/06	11/5/06	2	—	—	—
98	397	—	—	—	9/5/06	9/5/06	2
99	208	13/7/06	—	1	9/5/06	—	1
100	395	9/5/06	20/5/06	5	12/5/06	16/5/06	3
101	889	—	—	—	9/5/06	—	1

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Case 24. Attacked 9/5/06. House No. 135
Case 25. Attacked 9/5/06. House No. 881
Case 26. Attacked 9/5/06. House No. 757
Case 27. Attacked 9/5/06. House No. 776
Case 28. Attacked 9/5/06. House No. 8
Case 29. Attacked 9/5/06. House No. 391

		Plague-infected rats			Mummified or putrid rats		
Serial No.	House No.	First	Last	Total	First	Last	Total
102	346	10/5/06	—	1	—	—	—
103	94	11/5/06	—	1	10/5/06	—	1
104	24	10/5/06	—	1	—	—	—
105	861	10/5/06	—	1	—	—	—
106	159	10/5/06	—	1	—	—	—
107	1023	10/5/06	—	1	—	—	—
		Case 30. Attacked 10/5/06. House No. 759					
		Case 31. Attacked 10/5/06. House No. 486					
108	341	11/5/06	—	1	—	—	—
109	33	11/5/06	—	1	—	—	—
110	927	11/5/06	—	1	—	—	—
111	743	11/5/06	20/5/06	4	—	—	—
113	752	11/5/06	—	1	—	—	—
		Case 32. Attacked 11/5/06. House No. 391					
		Case 33. Attacked 11/5/06. House No. 43					
		Case 34. Attacked 11/5/06. House No. 256					
114	216	12/5/06	—	1	—	—	—
115	244	12/5/06	—	1	—	—	—
116	217	—	—	—	12/5/06	—	1
117	235	—	—	—	12/5/06	—	1
		Case 35. Attacked 12/5/06. House No. 422					
		Case 36. Attacked 12/5/06. House No. 767					
		Case 37. Attacked 12/5/06. House No. 225					
		Case 38. Attacked 12/5/06. House No. 133					
		Case 39. Attacked 12/5/06. House No. 134					
		Case 40. Attacked 12/5/06. House No. 818					
118	8	13/5/06	—	1	—	—	—
119	240	13/5/06	2/6/06	2	—	—	—
120	181	13/5/06	14/5/06	3	27/5/06	—	1
121	920	13/5/06	15/5/06	2	—	—	—
		Case 41. Attacked 13/5/06. House No. 391					
		Case 42. Attacked 13/5/06. House No. 158					
122	203	—	—	—	14/5/06	—	1
123	746	14/5/06	17/5/06	2	—	—	—
124	375	14/5/06	14/5/06	4	24/5/06	—	1
125	767	—	—	—	14/5/06	—	1
126	1003	14/5/06	—	1	—	—	—

Serial No.	House No.	Plague-infected rats: First	Last	Total	Mummified or putrid rats: First	Last	Total
		Case 43. Attacked 14/5/06. House No. 263					
127	135 (Lane)	15/5/06	—	1	—	—	—
128	371	15/5/06	20/5/06	2	—	—	—
129	373	15/5/06	20/5/06	4	24/5/06	24/5/06	2
130	256	15/5/06	—	1	—	—	—
131	454	—	—	—	15/5/06	—	1
		Case 44. Attacked 15/5/06. House No. 823					
		Case 45. Attacked 15/5/06. House No. 908					
132	785	16/5/06	—	1	—	—	—
133	185	16/5/06	—	1	—	—	—
134	791	16/5/06	—	1	20/5/06	—	1
135	750	—	—	—	16/5/06	—	1
136	727	16/5/06	25/5/06	3	—	—	—
		Case 46. Attacked 16/5/06. House No. 855					
		Case 47. Attacked 16/5/06. House No. 85					
		Case 48. Attacked 16/5/06. House No. 758					
		Case 49. Attacked 16/5/06. House No. 748					
137	156	17/5/06	—	1	—	—	—
138	226	—	—	—	17/5/06	—	1
139	754	—	—	—	17/5/06	—	1
		Case 50. Attacked 17/5/06. House No. 199					
		Case 51. Attacked 17/5/06. House No. 936					
		Case 52. Attacked 17/5/06. House No. 749					
140	379	—	—	—	18/5/06	—	1
141	337	18/5/06	—	1	—	—	—
142	232 (Compound behind)	18/5/06	—	1	—	—	—
143	731	18/5/06	—	1	—	—	—
		Case 53. Attacked 18/5/06. House No. 398					
		Case 54. Attacked 18/5/06. House No. 961					
144	1283	19/5/06	—	1	—	—	—
145	714	—	—	—	19/5/06	—	1
146	377	19/5/06	20/5/06	2	—	—	—
		Case 55. Attacked 19/5/06. House No. 979					
		Case 56. Attacked 19/5/06. House No. 981					
147	712	20/5/06	22/5/06	3	25/5/06	—	
		Case 57. Attacked 20/5/06. House No. 981					
148	732	21/5/06	—	1	—	—	—
149	35	21/5/06	—	1	—	—	—
150	31	21/5/06	—	1	—	—	—
151	1015	21/5/06	—	1	—	—	—
152	232	23/5/06	—	1	21/5/06	21/5/06	3

Serial No.	House No.	Plague-infected rats: First	Last	Total	Mummified or putrid rats: First	Last	Total
		Case 58. Attacked 21/5/06. House No. 754					
153	224	22/5/06	—	1	—	—	—
		Case 59. Attacked 22/5/06. House No. 102					
		Case 60. Attacked 22/5/06. House No. 672					
		Case 61. Attacked 22/5/06. House No. 917					
154	109	23/5/06	—	1	—	—	—
155	105	23/5/06	—	1	—	—	—
156	459	—	—	—	23/5/06	29/5/06	2
157	498	23/5/06	—	1	—	—	—
		Case 62. Attacked 23/5/06. House No. 244					
158	715	24/5/06	29/6/06	2	—	—	—
159	199	24/5/06	—	1	—	—	—
160	169	24/5/06	—	1	—	—	—
161	196	24/5/06	—	1	—	—	—
162	189	25/5/06	—	1	—	—	—
163	696	25/5/06	—	1	—	—	—
164	384	—	—	—	26/5/06	—	1
165	213	26/5/06	—	1	2/6/06	—	1
166	355	27/5/06	11/6/06	2	—	—	—
		Case 63. Attacked 27/5/06. House No. 744					
		Case 64. Attacked 28/5/06. House No. 923					
167	383	29/5/06	—	1	—	—	—
168	439	30/5/06	—	1	—	—	—
169	734	30/5/06	—	1	30/5/06	—	1
170	728	30/5/06	30/5/06	2	—	—	—
		Case 65. Attacked 30/5/06. House No. 230 A					
171	211	31/5/06	7/6/06	2	—	—	—
172	210	—	—	—	31/5/06	—	1
173	971	—	—	—	31/5/06	5/6/06	2
174	296	—	—	—	31/5/06	—	1
175	490	31/5/06	—	1	—	—	—
		Case 66. Attacked 31/5/06. House No. 175					
		Case 67. Attacked 31/5/06. House No. 207					
176	432	1/6/06	—	1	—	—	—
177	223	1/6/06	—	1	—	—	—
178	1042	2/6/06	—	1	—	—	—
179	1206	2/6/06	11/6/06	2	—	—	—
180	493	4/6/06	—	1	—	—	—
181	302	5/6/06	—	1	—	—	—
182	295	—	—	—	7/6/06	—	1
183	693	7/6/06	—	1	—	—	—
184	492	8/6/06	—	1	—	—	—
185	321	—	—	—	8/6/06	—	1

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Serial No.	House No.	Plague-infected rats: First	Last	Total	Mummified or putrid rats: First	Last	Total
		Case 68. Attacked 8/6/06. House No. 492					
186	485	10/6/06	—	1	—	—	—
187	601	10/6/06	—	1	—	—	—
188	1162	—	—	—	11/6/06	—	1
		Case 69. Attacked 11/6/06. House No. 1147					
		Case 70. Attacked 13/6/06. House No. 745					
189	1034	14/6/06	—	1	—	—	—
190	444	14/6/06	—	1	—	—	—
		Case 71. Attacked 14/6/06. House No. 270					
191	1036	15/6/06	—	1	—	—	—
192	138	15/6/06	—	1	—	—	—
193	615	15/6/06	—	1	—	—	—
194	297	15/6/06	—	1	—	—	—
195	316	20/6/06	—	1	15/6/06	—	1
196	686	16/6/06	29/6/06	2	—	—	—
197	272	16/6/06	—	1	—	—	—
		Case 72. Attacked 19/6/06. House No. 662					
		Case 73. Attacked 19/6/06. House No. 667					
198	552	21/6/06	—	1	—	—	—
199	508	21/6/06	—	1	—	—	—
200	700	23/6/06	26/6/06	2	—	—	—
201	682	26/6/06	—	1	—	—	—
		Case 74. Attacked 26/6/06. House No. 175					
202	698	4/7/06	—	1	—	—	—
		Case 75. Attacked 7/7/06. House No. 620					
203	669	9/7/06	—	1	—	—	—
204	643	17/7/06	—	1	—	—	—

houses in the same neighbourhood. Further, as we have already mentioned, about a week before the plague rat was found in their shop in Kasel, they had noticed a bad smell which they thought was due to a dead rat. This fact would suggest that the rats in this shop were actually the first in Kasel to become infected. It is quite possible, therefore; that the infection was brought from Dhand by the occupants of No. 122.

We have little to say as to the possibility of infection having been introduced into Kasel by infected rats which had migrated from another village. It is conceivable that such migration may have taken place from Dhand, which was the only infected village within three miles of Kasel. Had infection been introduced in this way we should, however,

PUNJAB IV

KASEL—PUNJAB

December, 1905 to November, 1906

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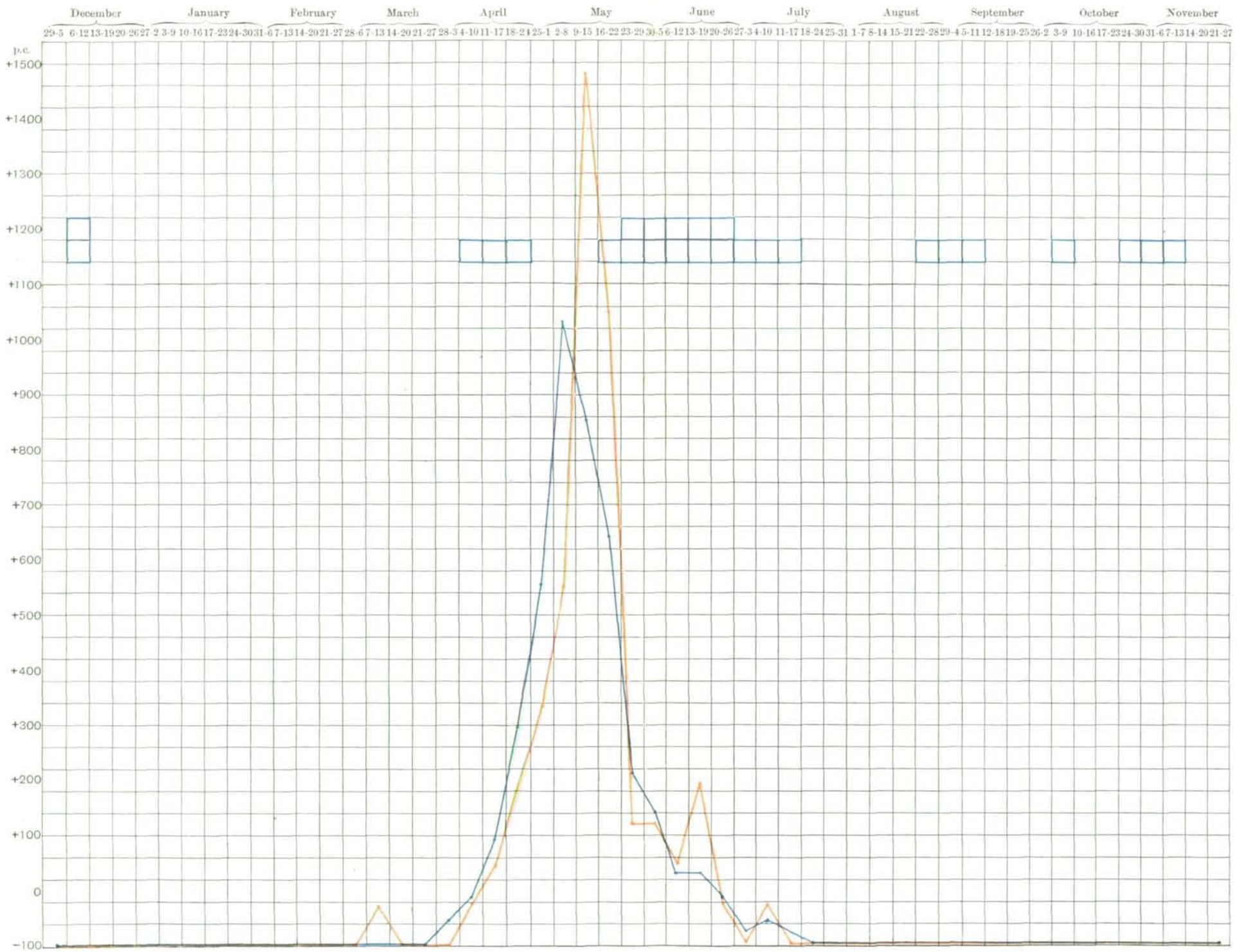

KASEL—PUNJAB

December, 1905 to November, 1906

— Plague infected rats (acute), p.c. above and below the mean

□ Chronic plague rats. One square = one rat

— Human plague attacks, p.c. above and below the mean

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TABLE XXVI.

Showing number of plague cases and plague-infected rats in Kasel week by week.

Weekly period ending	Plague cases	Plague deaths	Rats			
			Acute plague	Too putrid for diagnosis	Chronic plague	Grand Total
5/12/05	—	—	—	—	—	—
12/12/05	—	—	—	—	2	2
19/12/05	—	—	—	—	—	—
26/12/05	—	—	—	—	—	—
2/1/06	—	—	—	—	—	—
9/1/06	—	—	—	—	—	—
16/1/06	—	—	—	—	—	—
23/1/06	—	—	—	—	—	—
30/1/06	—	—	—	—	—	—
6/2/06	—	—	—	—	—	—
13/2/06	—	—	—	—	—	—
20/2/06	—	—	—	—	—	—
27/2/06	—	—	—	—	—	—
6/3/06	—	—	—	—	—	—
13/3/06	1	—	—	—	—	—
20/3/06	—	1	—	—	—	—
27/3/06	—	—	—	—	—	—
3/4/06	—	—	2	—	—	2
10/4/06	1	—	4	1	1	6
17/4/06	2	1	9	1	1	11
24/4/06	4	2	18	2	1	21
1/5/06	6	4	30	8	—	38
8/5/06	9	5	52	23	—	75
15/5/06	22	10	44	22	—	66
22/5/06	16	7	34	11	1	46
29/5/06	3	6	14	9	2	25
5/6/06	3	2	11	8	2	21
12/6/06	2	1	6	3	1	10
19/6/06	4	1	6	1	2	9
26/6/06	1	1	4	—	2	6
3/7/06	—	—	1	—	1	2
10/7/06	1	—	2	—	—	2
17/7/06	—	—	1	—	1	2
24/7/06	—	—	—	—	—	—
31/7/06	—	—	—	—	—	—
7/8/06	—	—	—	—	—	—
14/8/06	—	—	—	—	—	—
21/8/06	—	—	—	—	—	—
28/8/06	—	—	—	—	1	1
4/9/06	—	—	—	—	—	—
11/9/06	—	—	—	—	1	1
18/9/06	—	—	—	—	—	—
25/9/06	—	—	—	—	—	—
2/10/06	—	—	—	—	—	—
9/10/06	—	—	—	—	1	1
16/10/06	—	—	—	—	—	—
23/10/06	—	—	—	—	—	—
30/10/06	—	—	—	—	1	1
6/11/06	—	—	—	—	1	1
13/11/06	—	—	—	—	1	1
20/11/06	—	—	—	—	—	—
27/11/06	—	—	—	—	—	—
Total	75	41	238	89	23	350

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have expected that the epizootic would have begun on the outskirts of the village nearest to Dhand, instead of in the middle of the village.

Finally, with regard to the question of the origin of the epizootic by the lighting up of chronic rat plague into acute plague we need only point out that during the period before the epizootic no chronic plague rat had been taken in Kasel after the 12th December, 1905, namely, four months before the first acute plague rat was found. But it is important to note that the rats were not examined from 1st January to 20th February.

V. Relation between the Epizootic and Epidemic.

1. *Relation in time.*

The relation in time between the epizootic and epidemic becomes apparent by reference to Tables XXV and XXVI, and Chart 4. The latter shows the number of infected rats and the number of plague attacks for each week of the period during which observations were carried out in Kasel.

It will be seen from Table XXV, that the first acute plague rat was found on the 2nd April and the last on the 17th July, while the first indigenous human case was attacked on the 5th April and the last on the 6th July. During the remainder of the year the village was under observation no plague case occurred and no acute plague rat was found.

It will be seen from Chart 4 that the curves of rat plague and of human plague exhibit a very close correspondence, the variations of the curve of human plague following those of the rat plague curve at an interval of about a week.

It is evident then that in Kasel:

(1) Rat plague preceded human plague[1].

(2) Human plague ceased shortly before the cessation of acute plague among the rats.

(3) A quantitative relation existed between rat plague and human plague.

2. *Relation in place.*

This relation will be seen by reference to Maps 1 and also 3—16 and to Table XXV. Considered with reference to their association with plague rats the 75 plague cases may be grouped as follows:—

[1] The slight rise in the human plague attack curve before the rise in the epizootic curve was due to an imported case, namely, case 1.

Group A. Imported Cases.

I. *Cases suffering from plague when they arrived in Kasel.* The cases included in this group are two, namely, Nos. 1 and 6 (*vide* Appendix).

II. *Cases which were not attacked until after their arrival in Kasel, but whose infection was traced to sources outside the village.*

In this group are included two cases, namely, Nos. 5 and 11 (*vide* Appendix).

Group B. Indigenous Cases.

III. *Cases preceded by the finding of plague-infected rats in their actual residence.*

This group includes 25 cases, which occupied 19 houses. The cases are—Nos. 4, 7, 12, 15, 16, 20, 21, 25, 26, 29, 32, 33, 35, 41, 44, 48, 55, 56, 57, 59, 60, 63, 64, 68, and 70 (*vide* Appendix).

Further particulars regarding this group will be found in Table No. 28, to which we shall have occasion to refer later on.

IV. *Cases preceded by the finding of plague rats in the immediate neighbourhood, but not in the actual residence.*

This group includes 36 cases, namely, Nos. 8, 9, 10, 13, 14, 18, 19, 22, 23, 24, 27, 28, 30, 34, 36, 37, 38, 39, 40, 42, 43, 45, 46, 47, 49, 50, 51, 52, 53, 54, 58, 62, 65, 66, 74, and 75 (*vide* Appendix).

The degree of propinquity indicated by the expression "in the immediate neighbourhood" varies, and its value for any individual case must be determined by reference to the Appendix and Maps 1 and 3—16. That the association of the majority of the cases of this group with plague rats was, however, very close, will be apparent from the following additional details:—

(*a*) Plague rats were found in the houses immediately adjoining, and structurally one with, the residences of 13 cases, namely, Nos. 8, 9, 14, 18, 22, 23, 28, 30, 37, 42, 43, 65, and 66.

(*b*) Rats which were too putrid for diagnosis, in association with plague rats in the vicinity, were found in the actual residences of cases Nos. 24, 27, 30, 36, and 58, and in the houses immediately adjoining the residences of cases Nos. 13, 19, 38, 39, 47, 49, and 53.

(*c*) Plague rats were found in the residences of cases Nos. 28, 34, and 40, 4, 4, and 7 days, respectively, after attack. In 3 cases of this group, namely, Nos. 42, 54, and 62 (*vide* Appendix), it is difficult to correctly adjudge the place of infection.

Case 42. This case may have been infected either at his residence or at shop No. 255 which he frequented.

Case 54. We cannot suppose that the source of infection of this case was the plague rat found at her residence more than a month previous to her attack; on the contrary, the facts suggest that she owed her infection directly or indirectly to house No. 981.

Case 62. While the history of this case suggests that she was infected at Kasel, we cannot exclude the possibility of her having been infected at Hoshiarnagar.

V. *Cases not preceded by the finding of plague rats, either at their residence or in the immediate neighbourhood thereof.* Ten cases are included in this group, namely, Nos. 2, 3, 17, 31, 61, 67, 69, 71, 72, and 73.

These cases may be conveniently subdivided into:—

(1) Cases which had visited at infected houses prior to being attacked, and

(2) Cases in which the source of infection could not be definitely determined.

Sub-group (1) includes 6 cases, namely, Nos. 2, 3, 17, 31, 67, and 69.

The probable place of infection for each of these cases was as follows (*vide* Appendix):—

Case 2. House No. 121, where she visited, though infection at residence cannot be excluded.

Case 3. House No. 121, where she worked.

Case 17. House No. 249, where she worked.

Case 31. House No. 422, where she frequently visited.

Case 67. House No. 734, where she had stayed just before attack.

Case 69. House No. 492, where she visited.

Sub-group (2) includes 4 cases, namely, Nos. 61, 71, 72, and 73. Of these cases No. 61 was a doubtful case of plague. It is further to be noted that plague rats were found in the vicinity of the residences of the last three of these cases shortly after their attack.

We may summarise the data as regards the relation of the epizootic to the epidemic in place as follows:—

(1) Of 75 cases—4 were imported.

(2) Of the 71 indigenous cases 61 occurred in houses, in which or in the immediate vicinity of which plague-infected rats had been found prior to attack.

(3) Plague rats were not found in or near the residences of the remaining 10 cases prior to their attacks, but six of these cases had visited at houses where plague rats had been found.

(4) Of the remaining four cases one was a doubtful case, and plague

rats were found in the vicinity of the houses of the three other cases some days after they fell ill.

It will be apparent from what has been said above that we were able to trace a more intimate association between plague cases and plague rats in Kasel than we had succeeded in doing in Dhand. There is no doubt that this difference in the results obtained in the two villages can be, in part, explained by the fact that information of rats having died was obtained more readily in Kasel than in Dhand, as the Kasel people had ceased to look on us with suspicion at the time the epizootic began in their village.

TABLE XXVII.

Showing particulars of plague cases preceded by plague rats in the same house.

A. Plague cases occurring in houses in which dead plague rats were found only once.

House No.	Date of finding plague rats	Serial No. of cases	Dates of attack of cases	Interval between finding plague rats and cases
894	11/4/06	4	17/4/06	6 days
43	27/4/06 (2)	20 & 33	7/5/06 & 11/5/06	10 ,,
758	7/5/06	48	16/5/06	9 ,,
102	8/5/06	59	22/5/06	14 ,,
244	12/5/06	60	23/5/06	11 ,,

B. Plague cases which occurred in houses in which dead plague rats were found on more than one occasion.

House No.	Dates of finding plague rats	Serial No. of cases	Dates of attack of cases	Interval between 1st plague rat and 1st case	Interval between last plague rat and 1st case
902	14/4/06 & 18/4/06	7 & 21	20/4/06 & 8/5/06	6 days	2 days
246	20/4/06 & 24/4/06	12	28/4/06	8 ,,	4 ,,
81–82	23/4/06 & 1/5/06	15 & 16	2/5/06 & 3/5/06	9 ,,	1 day
881	22/4/06 & 27/4/06	25	9/5/06	17 ,,	12 days
757	4/5/06 & 8/5/06	26	9/5/06	5 ,,	1 day
391	29/4/06 & 2/5/06	29, 32 & 41	9/5/06, 11/5/06 & 13/5/06	10 ,,	7 days
422	5/5/06 & 7/5/06	35	12/5/06	7 ,,	5 ,,
823	30/4/06 & 3/5/06	44	15/5/06	15 ,,	12 ,,
979–980	8/5/06, 10/5/06 & 12/5/06	55	19/5/06	11 ,,	7 ,,
981	8/5/06, 9/5/06 & 11/5/06	56 & 57	19/5/06 & 20/5/06	11 ,,	8 ,,
744	11/5/06, 18/5/06, 19/5/06 & 20/5/06	63	27/5/06	16 ,,	7 ,,
923	9/5/06 & 11/5/06	64	28/5/06	19 ,,	17 ,,
492	4/6/06 & 8/6/06	68	8/6/06	4 ,,	—
745	16/5/06, 17/5/06 & 28/5/06	70	13/6/06	28 ,,	16 ,,

3. *Interval between the finding of dead plague rats in houses and the occurrence of the first plague case in them.*

Table XXVII shows that in the case of five houses, in which plague rats were found on only one occasion prior to attack, this interval varied from 6 to 14 days—the average interval being 10 days.

In 14 houses in which plague rats were found on more than one occasion prior to attack, the interval between the finding of the first plague rat and the first case varied from 5 to 28 days—the average being 12 days—while the interval between the last plague rat and the first case varied from 1 to 17 days, the average being 7 days.

It will be seen that these intervals correspond fairly closely with those deduced from the curves representing the *rattus* epizootic and the epidemic in Bombay. The explanation of this interval on the basis of the flea theory has already been discussed.

4. *Finding of plague-infected rats in houses not always followed by plague cases.*

The finding of plague rats in houses was not often followed by plague cases among the occupants. Thus, out of 86 occupied houses in which plague rats were found and in which evacuation was not carried out, only 15 or 17 % furnished cases. The risk of infection of the occupants appeared to increase with the number of plague rats found. Thus out of 80 houses in which single plague rats were found only 3, or 4 % of the whole, furnished cases, whereas plague cases among the occupants followed in 16 out of 57, or 28 %, of the houses in which more than one plague rat was found.

The above figures refer to dead plague rats only.

No plague case among the occupants occurred in any of 18 occupied houses in which live plague rats only were taken.

5. *The influence of evacuation of houses, in which dead plague rats were found, on the incidence of plague on the occupants.*

Evacuation as carried out in Kasel was either partial or complete.

Partial evacuation consisted in the occupants removing into the courtyard adjoining their house. In such cases communication with the house was not always completely cut off, as frequently one or more of the family went in and out for grain and other necessaries. Complete evacuation consisted in the occupants removing into another house and taking with them grain and other necessaries. Their

new residence was often at a distance from the evacuated house, with which they had, as a rule, no communication.

Of 137 occupied houses in which plague rats were found, 51 were evacuated within a day or two of the finding of the first plague rat. Of these about half were completely evacuated. In the remaining 86 houses the occupants did not turn out. The occupants of the 51 evacuated houses numbered 266, of which 27 had been recently inoculated. Of the remaining 239 susceptible persons 5, or 2 %, contracted plague. The occupants of the 86 houses, who did not turn out, numbered 418, of whom 14 were inoculated. Of the remaining 404 susceptible persons 20, or 5 %, contracted plague.

Although these figures are small they appear to warrant the conclusion that evacuation of houses soon after the finding of plague rats in them appreciably reduces the incidence of plague among the occupants.

APPENDIX.

Abstract of Plague Cases in Kasel.

Case 1.

Harnamoon, male, aet. 3, Chuhra. Residence—746, Kasel. Left Kasel with his parents about 1st March and went to Attari and later to a village named Narli in Lahore district. At Attari the family attended the mourning party of a Chuhra who is said to have died of fever. They went on to Narli about 3rd or 4th March. Narli was apparently infected with plague at the time they visited it. Harnamoon is said to have got fever about 9th March. He was brought back to house No. 746, Kasel on 12th March. When examined on 13th March he had high fever (105° F.) and axillary and cervical buboes. He died on 14th March. Material taken from bubo on 13th March—films and cultures positive.

Rats—No plague rats (excluding two chronic plague taken in December 1905) had been found in the village previous to this case.

Guinea-pig experiment—negative.

Connected cases—nil.

Case 2.

Hukamkour, female, aet. 35, Jat Sikh. Residence—68, Kasel. Had not left the village for some months. Frequently visited at house No. 121. The day before her attack she had visited a family of Nais in house No. 73. This family had just moved into No. 73 from No. 114, where plague-infected rats had been found the previous day. Attack—5th April; fever and right inguinal bubo; convalescent 10th April, bubo subsided without suppuration.

Rats—None in the house or immediate vicinity; but several plague rats in the neighbourhood of house No. 121 where she used to visit.

Guinea-pig experiments—A guinea-pig kept for night of 6th April in patient's house died of plague. No fleas were recovered from this pig.

Connected cases—nil.

Case 3.

Isso, female, aet. 10, Mehra (Hindu, water-carrier). Residence—1010, Kasel. Had not left the village. Previous to her attack used frequently to take water to house No. 121, as well as to other houses. Attack—15th April; fever, right femoral and inguinal buboes. Died during night of 17/4/06.

Rats—None at residence or in its vicinity prior to attack. Plague rats in the neighbourhood of house No. 121, where she worked (*vide supra*).

Guinea-pig experiments—negative.

Connected cases—nil.

Case 4.

Jiwan, female, aet. 60, Kamiar. Residence—894, Kasel. Attack—17th April; fever, right inguinal bubo first noticed on 19th April. Convalescent, 27th April; bubo subsided without suppuration.

Rats—A dead plague-infected rat found at residence on 11th April.

Connected cases—nil.

Case 5.

Lachmi, female, aet. 20, Sansi (a beggar tribe). Residence—1158, Kasel. Is said to have gone to a village, named Wadhala, in Amritsar Tahsil on or about 10th April to see her brother who was ill with plague there. Wadhala village was reported infected early in April. She returned to Kasel on or about 12th April. Attack—about 18th April, fever and right inguinal bubo. Examined on 20th April, temperature 105° F. Patient died on 26th April.

Rats—No plague rats found in house or anywhere near.

Guinea-pig experiments—negative.

Connected cases—nil.

Case 6.

Bhani, female, aet. 80, Mahomedan Kamboh. Residence—828, Kasel. Patient went to visit Majitha, a town in Amritsar Tahsil, about 12th April to visit her daughter, who was reported to be ill with plague there. Her daughter died the day after her arrival. Bhani was attacked with fever in Majitha about 18th April. She was brought back to Kasel by her son (Case 11) on 22nd April. When examined on 24th, for the first time, she was moribund. Her relatives gave a history of fever, cough and slight expectoration. No bubo was found on examination.

Rats—No plague rats at residence. The nearest plague rat prior to her attack was from house 842 on 14th April.

Connected cases—No. 11.

Case 7.

Umrdin, male, aet. 35, Mochi (shoemaker). Residence—902, Kasel. Had not left the village for some weeks before attack. Attack—20th April, fever, 104° F.; left axillary bubo on 22nd, died 24th April.

Rats—Dead plague-infected rats from residence on 14th and 18th April.
Connected cases—Nos. 8 and 9.

Case 8.

Jano, female, aet. 15, Mochi (shoemaker). Residence—901, Kasel. Came from a village in the Lahore district on 16th April. Frequently went to house No. 902 which adjoins and is occupied by relatives of her husband. Attack—24th April, fever and right inguinal bubo; died 4th May.

Rats—No plague rats at residence—but *vide* Case 7.
Connected cases—Nos. 7 and 9.

Case 9.

Sultanbibi, female, aet. 5, Mochi. Residence—901, Kasel. Has not left the village for some months. Attack—25th April, fever and right inguinal bubo. Died 27th April.

Rats—*Vide* Cases 7 and 8.
Connected cases—Nos. 7 and 8.

Case 10.

Ruri, female, aet. 35. Residence—897, Kasel. Had not left the village for many months before attack. Attack—25th April, fever and left inguinal bubo. Died 29th April.

Rats—No plague rats at residence; nearest infected rats from house No. 896 on 7th, and No. 894 on 11th April.
Connected cases—nil.

Case 11.

Alla Ditta, male, aet. 30, Mahomedan Kamboh. Residence—857, Kasel. Went to Majitha on 18th April to see his mother (Case 6), who was reported to be ill with plague there. He returned to Kasel alone next day, but again went to Majitha on 21st April and returned to Kasel on 22nd bringing his mother (Case 6) back with him. Attack—27th April, fever. Seen on 28th, temperature 103° F.; no bubo. Developed a cough with rusty expectoration on night of 29th. Temperature on 30th, 104° F.; expectoration copious and rusty. Died on 1st May. Sputum showed swarms of *B. pestis*-like organisms and a guinea-pig inoculated cutaneously died of typical plague.

Rats—No plague rats at residence, but several from houses 842, 843 and 869 in vicinity between 14th and 22nd April.
Guinea-pig experiment—negative.
Connected cases—No. 6.

Case 12.

Jhandoo, male, aet. 20, Bharai (beggar caste). Residence—246, Kasel (but 246, 247 and 248 are really one house). Had not left the village for a long time. When a plague rat was found in his house on 20th April, Jhandoo with his family moved into a neighbouring house, No. 263. Attack—28th April, fever and right femoral bubo; convalescent on 5th May; bubo subsided without suppuration.

Rats—Plague rats from residence (246) on 20th and 24th April.
Connected cases—Case 43 in same family.

Case 13.

Mamon, female, aet. 40, Mahomedan Kamboh. Residence—838, Kasel. Attack—28th April, fever and right inguinal bubo. Developed secondary plague pneumonia on 4th May. Premature delivery on 5th and died on 6th May. Sputum showed microscopically abundant bacilli like *B. pestis.*

Rats—None at residence but numerous plague rats in vicinity and a putrid rat from the next door house on 28th April.

Connected cases—nil.

Case 14.

Rakki, female, aet. 13, Mahomedan Kamboh. Residence—868, Kasel. Had not left the village for some time. Attack—30th April, fever and left femoral bubo. Died on 2nd May.

Rats—A plague rat found in the house immediately adjoining on 17th April.

Connected cases—nil.

Case 15.

Kisso, female, aet. 35, Hindu Nai. Residence—81 and 82, Kasel. Had not left the village for some weeks. Attack—2nd May, fever and left inguinal bubo. Died 5th May.

Rats—A live plague rat from her house on 17th April and a dead plague rat on 23rd April.

Connected cases—Nos. 16 and 18.

Case 16.

Rattoo, female, aet. 40, Hindu Nai. Residence—81, 82, Kasel. Attack—3rd May, fever and right femoral bubo. Died 6th May.

Rats—vide Case 15.

Connected cases—Nos. 15 and 18.

Case 17.

Dhani, female, aet. 10, Chuhra (sweeper). Residence—1243, Kasel. Had not left the village. Had gone daily to sweep out the courtyard of house No. 249, where a plague rat was found on 16th April. Attack—4th May, fever and left inguinal bubo. Seen on 6th May, temperature 99°, bubo very small and slightly tender. No abrasion of foot or leg could be found. Convalescent on 8th May. An attempt to obtain material from bubo on 6th May was unsuccessful; probably a case of Pestis Minor, but the diagnosis must be considered doubtful.

Rats—No plague rats at residence or anywhere in vicinity, but a plague rat at place of employment in house 249 (*vide supra*).

Guinea-pig experiments—negative.

Connected cases—nil.

Case 18.

Tejo, female, aet. 13, Hindu Nai. Residence—83, Kasel. Had not left the village for many months. Frequently went to visit at adjoining house 81, 82, the occupants of which were her relatives. Attack—5th May, fever and right inguinal bubo; convalescent on 12th May, bubo subsiding without suppuration.

Rats—No plague rats at residence, but plague rats in adjoining house 81, 82, *vide* Cases 15 and 16.

Connected cases—15 and 16.

Case 19.

Dyali, female, aet. 45, Chuhra (sweeper). Residence—775, Kasel. Had not left Kasel for many months. Attack—7th May, fever and right inguinal bubo. Died 13th May.

Rats—No plague rats at residence, but plague rats from house No. 779, which is quite close, on 25th and 26th April, and a putrid rat from adjoining house, No. 776, on 6th May.

Connected cases—nil.

Case 20.

Bhano, female, aet. 20, Mazbhi Sikh. Residence—43, Kasel. Had not left the village prior to attack. Attack—7th May, fever, bubo in the neck on 8th; convalescent on 18th May, bubo subsiding without suppuration.

Rats—Two plague rats from residence on 27th April.

Connected cases—No. 33.

Case 21.

Basakhi, male, aet. 25, Mochi. Residence—902, Kasel. Arrived in Kasel on 30th April from the Lahore district on learning of the death of Case 7, who was a relative of his. Attack—8th May, fever and right femoral bubo. Was removed to his own village on 12th May where he recovered.

Rats—Plague rats at residence on 14th and 18th April.

Connected cases—No. 8.

Case 22.

Wiroo, male, aet. 40, Arora (shopkeeper caste). Residence—Lived in a neighbouring village, Mianpur, but had a shop at No. 78, Kasel, where he came daily. The shop was kept by three brothers who slept in it by turns. Attack—fever on 8th May. Seen on 9th when his temperature was 102·2°, on 10th 103°, and on 11th 98·4° F. Patient was removed to his house at Mianpur on 12th May. He was seen there on 18th when he was found to have a left femoral bubo. Died on 19th May.

Rats—No history of dead rats at his house in Mianpur, although rats were dying in the village at the time he fell ill. Plague rats from house No. 81, 82, Kasel, which immediately adjoins his shop No. 78, on 17th and 23rd April.

Connected cases—nil.

Case 23.

Maghloo, male, aet. 80, Chuhra (sweeper). Residence—756, Kasel. Had not left Kasel recently. Attack—8th May, fever and right inguinal bubo. Died 12th May.

Rats—Plague rats from an adjoining house, No. 757, on 4th and 8th May.

Connected cases—nil.

Case 24.

Nihalo, female, aet. 30, Jat Sikh. Residence—135, Kasel. Attack—9th May, right femoral and inguinal buboes and fever. Convalescent on 18th May, bubo subsiding.

Rats—A putrid rat (unfit for diagnosis) at residence on 28th April.

Connected cases—Nos. 38 and 39, *vide* note after Case No. 39.

Case 25.

Karimbibi, female, aet. 7, Kamiar. Residence—881, Kasel, up to 24th April. On that date the family moved into house No. 882, which is close by, in consequence of a plague rat having been found in the former house on 22nd April. Attack—9th May, fever. Seen on 10th May when her temperature was 101·6° F. No bubo found on examination. On 12th May, temperature was 103·4° F.; on 13th, 105° F., and patient delirious. She died on the afternoon of 13th May without developing any bubo.

Rats—Plague rats from residence (house No. 881) on 22nd and 27th April.

Connected cases—nil.

Case 26.

Santoo, male, aet. 45, Chuhra. Residence—757, Kasel. Attack—9th May, fever, 104·6° F. and right femoral bubo. Temperature on 10th, 101·6° F., with marked slurring of speech. Convalescent on 11th May; bubo subsided without suppuration.

Rats—Dead plague rats from residence on 4th and 8th May.

Connected cases—nil.

Case 27.

Bhagan, female, aet. 40, Chuhra. Residence—776, Kasel. Attack—9th May, fever. Seen 10th May, temperature 101·6° F., small left femoral and inguinal buboes. Patient quite unconscious. Died on 12th May.

Rats—A putrid rat from residence on 6th May, and plague rats from house No. 779, which is quite near, on 22nd and 26th April.

Connected cases—nil.

Case 28.

Rajo, female, aet. 40, Jat Sikh. Residence—8, Kasel. Had not left the village prior to attack. Attack—9th May, right inguinal bubo and fever. Seen on 10th May, temperature 105° F. Died on 13th May.

Rats—Dead plague rats from residence after attack (13th May). Plague rats from houses Nos. 923 and 938, which immediately adjoins No. 8, on 9th and 11th May.

Connected cases—nil.

Case 29.

Lachmi, female, aet. 22, Brahmin. Residence—391, Kasel. Had not left the village for 5 months before attack. Attack—9th May, pain in right axilla. On 10th right axillary bubo, temperature 101·6° F. Gave birth to a full term living child on 13th and died on 14th May.

Rats—Dead plague rats from residence on 29th April and 2nd May, and from an adjoining house, No. 392, on 5th, 6th and 7th May.

Connected cases—32 and 41.

Case 30.

Chuhru, male, aet. 2, Chuhra. Residence—759, Kasel. Had not left the village since birth. Attack—10th May, fever and left axillary bubo. Died on 11th May.

Rats—A putrid rat from residence on 4th May. Plague rats from adjoining houses, Nos. 757, 758, and 769, between 25th April and 8th May.

Connected cases—nil.

Case 31.

Khem-Kaur, female, aet. 35, Jat Sikh. Residence—486, Kasel. Had frequently visited at house No. 422 prior to her illness. Attack—10th May, with fever. First seen on 15th when her temperature was 102·4° F. No bubo found on examination. On 16th temperature was 102·8° F., on 17th 103·2° F., and patient was unconscious. On this date a small blister, about the size of a sixpence, was noticed below the right external malleolus. The relatives would not allow us to take material from the blister for bacteriological examination. Patient died on 17th May.

Rats—None at residence or in the vicinity till a month later. Several plague rats from house No. 422 (where patient used to visit) on 5th and 7th May.

Connected cases—nil.

Case 32.

Atma Ram, male, aet. 35, Brahmin, husband of Case 29. Residence—391, Kasel. Attack—11th May, fever, on 12th temperature 101·6° F., no bubo. Inguinal bubo appeared on 14th, temperature 101° F. Convalescent on 15th May; bubo subsided without suppuration.

Rats—vide Case 29.

Connected cases—Nos. 29 and 41.

Case 33.

Gango, female, aet. 20, Mazbhit, sister-in-law of Case 20. Residence—43, Kasel. Attack—11th May. Examined on 12th. Temperature 101·4° F.; right inguinal bubo, a small papule noticed below right anterior superior iliac spine which patient said had appeared on 10th May. This subsequently developed into a small carbuncle. Patient convalescent on 17th May.

Rats—vide Case 20.

Connected case—No. 20.

Case 34.

Gulabi, female, aet. 35, Jat Sikh. Residence—256, Kasel. Attack—11th May. Case examined 13th May, temperature 104·4° F. and right inguinal bubo. Died on 14th May.

Rats—A plague rat from residence on 15th May. Numerous plague rats from house No. 255, which almost adjoins No. 256, between 5th May and 12th May.

Connected cases—nil.

Case 35.

Durgo, female, aet. 8, Brahmin. Residence—422, Kasel. Had not left the village for several months before attack. Attack—12th May. Examined on 14th May, temperature 103·2° F., left axillary bubo. Died on 17th May.

Rats—Plague rats from residence on 5th and 7th May and a putrid rat on 8th May.

Connected cases—nil.

Case 36.

Alpal, male, aet. 40, Chuhra. Residence—767, Kasel. Attack—12th May. Examined the same day, temperature 102° F., right inguinal bubo. Died 16th May.

Rats—A putrid rat from residence on 14th May. Plague rats from house No. 769, which is quite near, on 1st May.

Connected cases—nil.

Case 37.

Hazara Singh, male, aet. 7, Jat Sikh. Residence—225, Kasel. Attack—12th May, fever. Examined 13th May, temperature 106° F., no bubo found. On 14th patient delirious, temperature 102° F. Died at midnight without developing a bubo.

Rats—No plague rats at residence. Plague rat from an adjoining house, No. 218, on the 6th May and from No. 216 on 12th May.

Connected cases—nil.

Case 38.

Jaro, female, aet. 7, Jat Sikh. Residence—133, Kasel. Attack—14th May, fever and bubo. Examined 14th May, temperature 103° F. Right femoral and right posterior cervical buboes. Convalescent on 17th May.

Rats—No plague rats at residence. A putrid rat from adjoining house, No. 135, on 28th April, and a dead plague rat in lane adjoining residence on 15th May.

Connected cases—Nos. 24 and 39.

Case 39.

Khemi, female, aet. 30, Jat Sikh. Residence—134, Kasel, in house immediately adjoining No. 133 and in same courtyard. Attack—12th May, fever and right femoral bubo. Examined on 13th, temperature 102° F. Convalescent on 21st May; bubo subsided without suppuration.

Rats—vide Case 38.

Connected cases—Nos. 24 and 38.

The occupants of houses Nos. 133, 134 and 135 are three brothers and their families, and it appears that Cases 38 and 39 frequently went to house 135 while Case 24 was ill there.

Case 40.

Jioni, female, aet. 25, Mahomedan Kamboh. Residence—818, Kasel. This woman left Kasel on 9th May accompanied by Bhagi (*vide* Case 46) to attend the mourning ceremonies of a relative who had died 7 days previously in a village, named Singhpur, in the Lahore District. This relative is said to have died from gout. Jioni and Bhagi returned together to Kasel on 10th May. Attack—12th May. Examined on 13th May, temperature 101° F., left inguinal bubo. Died on 14th May.

Rats—No plague rats from residence. Two putrid rats from a neighbouring house (No. 827) on 29th April and plague rats from houses Nos. 806 and 807 on 1st and 2nd May.

Connected cases—no evidence could be obtained as to whether this case was exposed to infection at Singhpur. The fact of both Jioni and Bhagi (Case 46) having gone to Singhpur together would suggest that they had been infected there. On the other hand Case 46 was not attacked till six days after her return from Singhpur, and again plague rats had been found in the vicinity of the houses of both cases in Kasel.

Case 41.

Har Kour, female, aet. 50, Brahmin. Residence—391, Kasel. This patient came from a village, called Boparam, in the Amritsar District, about the 24th April to look after Lachmi (Case 29), who was then nearing her confinement. Attack—

13th May, fever and left femoral bubo. Seen on 14th, temperature 105° F., on 15th, 104·4° F. Patient was removed to her own house on 16th April and died on the way there.

Rats—*vide* Case 29.

Connected cases—Nos. 29 and 32.

Case 42.

Matharoo, male, aet. 7, Khatri (shopkeeper caste). Residence—158, Kasel. Previous to attack he went almost daily to his brother's shop, No. 255, Kasel. He was inoculated against plague on 9th May. Attack—bubo and fever on 13th May. Examined 14th May—temperature 102·8° F., right inguinal bubo. A left inguinal bubo appeared on 17th. Convalescent on 21st May, both buboes subsiding.

Rats—No plague rats at residence, but a dead plague rat from No. 159, a house adjoining his residence, on 10th May. Numerous plague rats from his brother's shop, No. 255, between 5th and 12th May.

Connected cases—nil.

Case 43.

Sammooo, male, aet. 8, Bharai (beggar tribe). Residence—246 and 247, Kasel; but was living temporarily in 263, Kasel when attacked. This boy left Kasel soon after his family moved into house No. 263 (*vide* Case 12), namely about the 25th April. He stayed with his uncle in a village, named Chak, in the Tarn Taran Tahsil, up to 9th May, when he returned to Kasel. On his return he stayed with his family in house No. 263, and it is said that he did not go into his own house (246, 247) after his return to Kasel. Attack—14th May. Examined 15th May, temperature 103·2° F., left cervical bubo; 16th May, temperature 101·2° F., convalescent on 21st May, bubo subsiding.

Rats—Plague rats at former residence, viz., house No. 246, 247 (*vide* Case 12). No plague rats from house No. 263, but a dead plague rat from No. 250, immediately adjoining, on 2nd May.

Connected cases—No. 12.

Case 44.

Ranga, male, aet. 35, Mahomedan Kamboh. Residence—823, Kasel. Attack—15th May. Examined 17th, temperature 100·2° F. and left axillary bubo. 18th, temperature 98·8° F. Convalescent on 20th May, bubo subsiding.

Rats—Plague rats from residence on 30th April and 3rd May.

Connected cases—nil.

Case 45.

Laldin, male, aet. 30, Mochi (shoemaker). Residence—908, Kasel, and works in an adjoining room, No. 909. Attack—15th May, pain in left femoral glands. Examined 16th May, temperature 100·8° F., left femoral bubo. 17th, temperature 104·8° F. Died on 18th May.

Rats—No plague rats from residence, but numerous plague rats from house 255 between 5th and 12th May. House No. 909 opens by a small door on to the street opposite No. 255.

Connected cases—nil.

Case 46.

Bhagi, female, aet. 40, Mahomedan Kamboh. Residence—855, Kasel. For movements prior to attack, *vide* Case 40. Attack—16th May, bubo and fever. Examined 17th May, temperature 103° F., left inguinal bubo; 18th, temperature 103·6° F.; convalescent 24th May, bubo subsiding.

Rats—Plague rats from house No. 861 in the vicinity on 10th May.

Connected cases—nil.

Case 47.

Basant-Kaur, female, aet. 25, Jat Sikh. Residence—85, 86, Kasel. Attack—16th May. Examined 17th May, temperature 101·4° F., left femoral bubo. Died 25th May.

Rats—A putrid rat from house No. 87, in the same courtyard and immediately opposite residence, on 9th May. Plague rat from house No. 94 in the immediate vicinity on 11th May.

Connected cases—nil.

Case 48.

Gujjari, female, aet. 45, Chuhra. Residence—758, Kasel. Attack—16th May. Examined 17th, temperature 102·8° F., right axillary bubo; a small recent scar seen on front of right forearm said to be due to a burn. Convalescent on 21st May.

Rats—A plague rat from residence on 7th May and plague rats from the adjoining house (No. 757) on 4th and 8th May.

Connected cases—nil.

Case 49.

Jiwan, female, aet. 30, Chuhra. Residence—748, Kasel. Attack—16th May. Examined 17th, temperature 102·6° F.; left inguinal bubo; 18th, temperature 104° F.; patient gave birth to a child (about a week before expected term). Died on 19th May.

Rats—None found at residence. A putrid rat from adjoining house, No. 750, on 16th May, and a plague rat from house No. 752 on 11th May and several recent plague rats from other houses in the vicinity.

Connected cases—nil.

Case 50.

Jagga Singh, male, aet. 16, Jat Sikh. Residence—199, Kasel. Attack—17th May. Examined same day, temperature 102·6° F., right cervical bubo; 18th, temperature 99° F.; 19th, temperature 98·4° F., a second bubo in left femoral region appeared this day; 20th, temperature 104° F. Died on 23rd May.

Rats—A plague rat from residence on 24th May. Plague rats from house No. 181 in the immediate vicinity on 13th and 14th May.

Connected cases—nil.

Case 51.

Biban, female, aet. 30, Mochi. Residence—936, Kasel. Attack—17th May. Examined 18th, temperature 100·2° F., left femoral bubo. Convalescent on 19th, bubo subsided.

Rats—No plague rats at residence, but a plague rat on 8th May from house No. 935 in the adjoining courtyard.

Connected cases—No. 64.

Case 52.

Gabo, female, aet. 7, Chuhra. Residence—749, Kasel. Attack—17th May. Examined 18th May, temperature 103° F., right inguinal bubo. Died 25th May.

Rats—No plague rats from residence, but a putrid rat from adjoining house, No. 750, on 16th, and a plague rat from house No. 752 on 11th May.

Connected cases—nil.

Case 53.

Jawali, female, aet. 30, Brahmin. Residence—398, Kasel. Attack—18th May. Examined on same date, temperature 102° F., spleen much enlarged and tender, no bubo admitted. On 19th, temperature 100° F., on 20th, 101° F., on 21st, 103·6° F., and delirious. Died on 21st May.

Rats—No plague rats from residence. Putrid rats from house No. 397, which immediately adjoins residence, on 9th May, and numerous plague rats from house No. 395 immediately opposite, between 9th and 20th May.

Connected cases—nil.

Case 54.

Natho, female, aet. 50, Kamboh. Residence—961, Kasel. This woman is a relative of the occupants of house No. 981. As far as could be ascertained she did not visit at this house, but one of the inmates of No. 981 (Khairdin) used to visit frequently at house 961 (*vide* Case 57). Attack—18th May, fever. Examined 20th, temperature 100·2° F., left femoral bubo; 21st, temperature 103·6° F. Convalescent on 30th May.

Rats—A plague rat from residence on 15th April; no plague rats from the immediate vicinity since 23rd April, but a plague rat from house No. 861 on 10th May, and one from house No. 953 on 5th May. As mentioned above, Khairdin, from house No. 981, was a constant visitor at her house, No. 961, at a time when plague rats were being found in the former house. Khairdin was himself attacked with plague on 20th May.

Connected case—No. 57.

Case 55.

Barkate, female, aet. 10, Kamboh. Residence—979, 980, Kasel. Inoculated against plague on 11th May. Attack—19th May. Examined on same date, temperature 102·2° F., left femoral bubo; 20th, temperature 102·2° F.; 21st, temperature 101° F.; 22nd, 98·4° F. Patient convalescent on 22nd May, bubo subsiding.

Rats—Plague rats from residence on 8th, 10th, and 12th May.

Connected cases—56 and 57, who are relatives living in the adjoining house, and both of whom came into contact daily with Case 55.

Case 56.

Ruckamdin, male, aet. 16, Kamboh. Residence—981, Kasel. Attack—19th May. Examined 21st, temperature 103° F., left femoral bubo; 22nd, temperature 104·4° F. Died 23rd May.

Rats—Plague rats from residence on 8th, 9th, and 11th May.

Connected cases—55 and 57.

Case 57.

Khairdin, male, aet. 40, Kamboh. Residence—981, Kasel. Attack—20th May. Examined 22nd, temperature 101·6° F., right femoral bubo; 23rd, temperature normal, convalescent. Bubo subsided.

Rats—vide Case 56.

Connected cases—Nos. 54, 55 and 56.

Case 58.

Bholi, female, aet. 30, Chuhra. Residence—754, Kasel. Attack—22nd May. Examined 23rd, temperature 100° F., left femoral bubo; 24th, temperature normal, convalescent. Bubo subsided.

Rats—A putrid rat from residence on 17th May and a plague rat from house No. 752 on 11th May.

Connected cases—nil.

Case 59.

Harkaur, female, aet. 20, Jat Sikh. Residence—102, Kasel. Attack—22nd May. Examined 23rd May, temperature 102° F., right femoral bubo; 24th, temperature 103° F. Died 28th May.

Rats—A plague rat from residence on 8th May and two putrid rats on 9th May.

Connected cases—nil.

Case 60.

Basant Kaur, female, aet. 25, Jat Sikh. Residence—244, Kasel. Attack—23rd May. Examined 24th May, temperature 101·8° F., left inguinal bubo; 25th, temperature 104° F. Convalescent on 1st June. Bubo suppurated.

Rats—A plague rat from residence on 12th May.

Connected cases—nil.

Case 61.

Hasain Mahommed, male, aet. 3, Jal. Residence—672, Kasel. Attack—22nd May. Examined 23rd May, temperature 101° F., parotid swellings on both sides resembling mumps. Swellings not hard and not very tender; 24th, temperature 98° F.; did not appear very ill, but died suddenly in the evening. Clinically the disease had all the appearance of mumps. No material was obtained for bacteriological examination; but, in view of the rapidly fatal issue, we consider the case highly suspicious, and have included it among the cases of plague.

Rats—No plague rats at residence or in the vicinity till some time after.

Case 62.

Tabo, female, aet. 30, Kamboh. Residence—917, Kasel. This woman lived with her husband in Hoshiarnagar, a village about three miles from Kasel. She came to visit her mother at No. 917, Kasel, during the first week in May and remained there up to 21st May, when she returned to her husband. On the day following her return to Hoshiarnagar she is said to have got fever, and a few days later developed a bubo in the right groin. She was brought back to a farm house about one mile from Kasel on 27th May. Examined on 28th May, temperature 101° F., right inguinal bubo.

Rats—No plague rats from residence in Kasel, but two plague rats from house No. 920, which is the next house but one, on 13th and 15th May. Plague existed in Hoshiarnagar from about the middle of April, and it was learned that a relative of Tabo's husband had died of plague there about the time she came to Kasel.

Case 63.

Kisso, female, aet. 18, Chuhra. Residence—744, Kasel. Attack—27th May. Examined 28th, temperature 104·8° F., left femoral bubo; 29th, temperature 104·2° F. Patient was removed to another village on this date, and it was subsequently learned that she recovered.

Rats—Plague rats from residence on 11th, 18th and 19th May.

Connected cases—nil.

Case 64.

Nathoo, male, aet. 10, Mochi. Residence—923, Kasel. This boy with his family vacated their house, No. 923, on 10th May in consequence of their finding a plague rat there on 9th May, and went to live in house 936, where Case 51 was attacked on 17th. The family returned to house 923 on 26th May. Attack—28th May. Examined 29th, temperature 104·2° F., right axillary bubo; 30th, temperature 103·2° F.; 31st, normal, bubo subsiding.

Rats—Plague rats from house 923 on 9th and 11th May. For rats in vicinity of house No. 923, *vide* Case 51.

Connected case—No. 51.

Case 65.

Jawali, female, aet. 40, Jat Sikh. Residence—230, Kasel, which is a "chaubara" (upper room) built on the roof of house No. 233. Previous to her attack she went daily to house No. 232, 233, where she had relatives. Attack—30th May. Examined 1st June, temperature 102° F., left inguinal bubo and a small phlyctenule on left buttock; 2nd June, temperature 102·2° F., phlyctenule had become a carbuncle; 3rd June, temperature 102·2° F., carbuncle large and very painful; 4th June, temperature 102·6° F., a crucial incision was made into carbuncle; 5th June, temperature 102·6° F.; 6th June, temperature 98·4° F., convalescent; bubo subsided without suppuration. Bacteriological examination of serum from the phlyctenule-smears and cultures—positive.

Rats—No plague rats at residence, but plague rats, on 7th and 23rd May, from house 232, 233, where case visited. Numerous plague rats from No. 395, which adjoins residence, between 9th and 20th May.

Connected cases—nil.

Case 66.

Jaina, female, aet. 16, Mahomedan Teli (oil extractor caste). Residence—175, Kasel. Attack—31st May. Examined 2nd June, temperature 102° F., left femoral bubo; 3rd June, temperature 104° F., cervical buboes on both sides, which appeared during the night. Died on 4th June.

Rats—No plague rats at residence, but from adjoining houses, Nos. 156 and 159, on 17th and 10th May respectively.

Connected case—No. 74 in same house, but not attacked till 26th June.

Case 67.

Har Kour, female, aet. 80, Jat Sikh. Residence—no fixed abode for many months, though she owns house No. 207, which she went to after attack. This case used to go from house to house, and it is difficult to trace her movements prior to her illness. As far as could be ascertained, she lived in the courtyard of house No. 63, Kasel, till the 31st May. On that date she is said to have got fever, and was asked to go elsewhere. She went in the afternoon of 31st May to house No. 734 and remained there till 2nd June, when she was removed to her own house, No. 207. Attack—probably on 31st May. Examined on 3rd June, temperature 100·6° F., cough and copious expectoration of blood-tinged sputum. Died in the afternoon. Sputum examined microscopically and found to contain abundant organisms like *B. pestis.*

Rats—A putrid rat from house 63 on 8th May. Plague rats at house 734 on 30th May.

Connected cases—not ascertained.

Case 68.

Ramzano, female, aet. 12, Mahomedan Fakir (beggar tribe). Residence—492, Kasel. Attack—8th June. Examined 9th June, temperature 104·2° F., left axillary bubo, delirious; 10th June, temperature 104·2° F. Died on 11th June.

Rats—A plague rat at residence on 8th June. A plague rat from house 493, immediately adjoining, on 4th June, and from No. 490 in the same courtyard on 31st May.

Connected case—No. 69.

Case 69.

Budho, female, aet. 7, Mahomedan Fakir. Residence—1147, Kasel. This child was a relative of Ramzano (Case 68), and frequently visited at the latter's house (No. 492) both before and during her illness, and attended her funeral party on 11th June. Attack—11th June. Examined 12th, temperature 104·4° F., right inguinal bubo, unconscious; 13th, temperature 104·4° F.; 14th, temperature 100° F.; 15th, temperature 102·8° F. Died on this date.

Rats—None at residence or in its vicinity. Plague rats at house No. 492 (*vide* Case 68).

Case 70.

Bahadur, male, aet. 7, Chuhra. Residence—745, Kasel. Attack—13th June. Examined 14th, temperature 102·8° F., right cervical bubo; 15th, temperature normal, convalescent, bubo subsided.

Rats—Several plague rats from residence, the last on 28th May.

Connected cases—nil.

Case 71.

Gulab, male, aet. 40, Kamboh. Residence—270, Kasel. Attack—14th June. Case examined on 16th, temperature 103·2° F., left femoral bubo; 17th, temperature 101·2° F.; 18th, temperature normal, convalescent. Bubo subsided.

Rats—No plague rats at residence. A live plague rat from an adjoining house (272) on 16th June.

Connected cases—nil.

Case 72.

Gulab Fatma, female, aet. 3, Moh. Chhumba (washerman caste). Residence—662, Kasel. Attack—19th June. Examined 21st June, temperature 104·2° F., left femoral bubo; 22nd, temperature 103·2° F. Died on this date.

Rats—No plague rats at residence or in its vicinity previous to attack; plague rats from house 700 on 23rd and 26th June.

Connected cases—nil.

Case 73.

Fazal-bibi, female, aet. 16, Teli. Residence—667, Kasel. Attack—19th June. Case examined on 21st, temperature 104·2° F., right femoral bubo; 22nd, temperature 102° F. Convalescent on 28th June, bubo subsiding.

Rats—No plague rats at residence and no recent plague rats in the vicinity prior to attack, but plague rats from an adjoining house, No. 700, on 23rd and 26th July.

Connected cases—nil.

Case 74.

Tuli, male, aet. 7, Teli, brother of Case 66. Residence—175, Kasel. Is a relative of occupants of house No. 211, 212, Kasel, and frequently goes there. Attack—26th June, fever and right femoral bubo. Examined 28th June, temperature normal, and a small tender gland in right femoral region. Patient was convalescent on this date, and bubo subsided in a few days. No abrasion or wound could be found to account for the femoral swelling.

Rats—A live plague rat from house No. 138 in the vicinity of residence on 15th June. Plague rats on 31st May and 7th June at house 211, 212, where case used to visit.

Connected case—No. 66 in same house.

Case 75.

Assa Singh, male, aet. 30, Jat Sikh. Residence—620, Kasel. Attack—6th July, with fever, headache, and a bubo in right groin. First seen on 8th July, when his temperature was normal. A small, slightly tender right femoral bubo found on examination. No abrasion that would account for the bubo found. Patient went to work on this date, and bubo quickly subsided.

Rats—No plague rats from residence, but one from house No. 615 in the same compound on 15th June.

Connected cases—nil.

TABLE XXVIII.

Experiments with guinea-pigs running free in plague houses.

Serial No.	Date	Address	No. of guinea-pigs put in	No. of fleas caught on guinea-pigs	No. of guinea-pigs which died of plague	Remarks
1	30/1/06	347 Dhand	2	48	—	Live plague rats caught on 27/1/06. One of the guinea-pigs died under chloroform, on this 40 of the fleas were found
2	1/2/06	,,	1	30	—	Kept in back room of house No. 347, which had remained closed for more than a year
3	2/2/06	156 Dhand	1	12	—	Live plague rat on 30/1/06
4	2/2/06	342 Dhand	1	2	—	Live plague rat on 30/1/06
5	9/2/06	352 Dhand	1	16	—	Plague case on 6/2/06
6	9/2/06	349 Dhand	1	5	1	Plague case on 7/2/06
7	10/2/06	350 Dhand	1	16	1	Dead plague rat on 9/2/06
8	15/2/06	498 Dhand	1	—	—	Plague case on 13/2/06, but probably infected in house No. 350
9	15/2/06	340 Dhand	1	2	—	Plague case on 12/2/06
10	15/2/06	338 Dhand	1	—	—	Plague case on 13/2/06: guinea-pig put in upper room where case lived
11	21/2/06	,,	1	—	—	Guinea-pig put in bhoosa godown in ground floor
12	21/2/06	181 Dhand	1	1	—	Plague case on 16/2/06
13	23/2/06	378 Dhand	1	7	1	Plague case on 22/2/06: guinea-pig put in back room
14	25/2/06	,,	1	2	—	Two more plague cases on 24/2/06: guinea-pig put in living room
15	24/2/06	439 Dhand	2	4	—	Plague rat dead on 23/2/06
16	8/3/06	335 Dhand	2	2	—	Plague case on 5/3/06
17	16/3/06	746 Kasel	2	28	—	Imported plague case on 12/3/06
18	24/3/06	159 Dhand	2	26	—	Plague case on 22/3/06
19	27/3/06	357 Dhand	2	—	—	Suspicious case of plague on 25/3/06
20	29/3/06	402 Dhand	1	9	1	Dead plague rat on 28/3/06
21	31/3/06	39 Dhand	2	108	2	Plague case on 28/3/06
22	1/4/06	15 Dhand	1	25	1	Dead plague rats on 24/3/06 and 31/3/06: house vacated on latter date
23	3/4/06	122 Kasel	1	9	—	Dead plague rat on 2/4/06

24	4/4/06	114	Kasel	1	70	1	Dead plague rats on 3/4/06 and 4/4/06
25	7/4/06	68	Kasel	1	—	1	Plague case on 5/4/06
26	9/4/06	3	Dhand	1	—	—	Plague case on 7/4/06
27	10/4/06	225	Dhand	1	8	—	Plague cases on 4/4/06 and 7/4/06, but *vide* Table IV, No. 15
28	12/4/06	622	Dhand	1	7	—	Plague cases (2) on 10/4/06
29	17/4/06	589	Dhand	2	—	—	Plague case on 14/4/06
30	17/4/06	1010	Kasel	1	60	—	Plague case on 15/4/06
31	20/4/06	587	Dhand	1	—	—	Plague case on 14/4/06
32	21/4/06	583	Dhand	1	11	—	Live plague rat on 1/4/06: plague case on 19/4/06. Guinea-pig died under chloroform, but another guinea-pig on which its fleas were fed died of plague
33	23/4/06	1158	Kasel	1	9	—	Plague case on 18/4/06, but probably infected in another village
34	25/4/06	588	Dhand	1	1	—	Plague case on 20/4/06
35	25/4/06	220	Dhand	1	136	1	Plague case on 23/4/06
36	26/4/06	2	Dhand	1	1	—	Suspicious plague case on 21/4/06
37	1/5/06	857	Kasel	1	3	—	Plague case (pneumonic) on 27/4/06, probably infected in another village
38	4/5/06	386	Dhand	1	8	—	Plague case on 1/5/06
39	4/5/06	387	Dhand	1	30	—	Plague case on 2/5/06
40	7/5/06	1243	Kasel	1	—	—	Suspicious plague case on 4/5/06, probably infected elsewhere in the village
41	28/5/06	672	Kasel	1	—	—	Suspicious case on 22/5/06, clinically like mumps, but rapidly fatal
42	15/6/06	1147	Kasel	1	2	—	Plague case on 11/6/06, but probably infected in house No. 492
43	15/6/06	745	Kasel	1	5	—	Plague rat dead on 28/5/06, plague case on 13/6/06
44	17/6/06	270	Kasel	1	2	—	Plague case on 14/6/06
45	22/6/06	662	Kasel	1	3	—	Plague case on 19/6/06
46	25/6/06	667	Kasel	1	5	—	Plague case on 19/6/06
47	5/7/06	698	Kasel	1	—	—	Dead plague rat on 4/7/06: guinea-pig died on 12/7/06, not from plague
48	9/7/06	620	Kasel	1	—	—	Suspicious case of pestis minor on 7/7/06
49	10/7/06	669	Kasel	1	—	—	Dead plague rat on 9/7/06

V. EXPERIMENTS IN PLAGUE HOUSES IN DHAND AND KASEL.

In two papers already published (vol. VI. p. 467, vol. VII. p. 436) we have detailed several series of experiments which we carried out in plague houses in Bombay during the plague epidemics of 1906 and 1907. These observations went to prove, both directly and indirectly, that in a plague-infected house the infection is due to the presence therein of infected rat fleas, which are capable of transmitting the disease to animals.

Exactly similar series of experiments have been made in plague houses in Dhand and Kasel during the time plague was epidemic in these villages. We propose now to detail these observations, classifying them in the same way as has been done for Bombay. In the houses selected for experiment either a dead rat or rats had been found, which in many instances were proved to be plague infected at the laboratory, or a human case or cases had occurred or, in a few instances, both a dead rat had been found and a plague case had occurred.

The observations conveniently fall into three groups.

GROUP I.

Series I.

Experiments with guinea-pigs running free in plague houses.

In this group guinea-pigs were allowed to run free for about eighteen hours in houses selected in the manner we have mentioned above. As a general rule only one guinea-pig was put into each house, but in a few instances two were used.

The details of the experiments of this series are contained in Table XXVIII.

This shows that out of 49 houses tested in this way nine, namely 18·4 %, were infective for the guinea-pigs. In all ten guinea-pigs contracted the disease. The distribution of the primary bubo in these ten animals was as follows: no bubo 2; neck alone 5; groin alone 2; neck and groin 1: so that in six out of eight cases with buboes the neck glands were affected.

Table XXIX shows the average number of fleas taken in each of four groups of houses:—A, houses which were infective for guinea-

pigs: B, houses which were not infective for guinea-pigs: C, houses which were proved to be plague infected, because a rat proved to be plague infected had been found in the house, or because the guinea-pig developed the disease, or because both a plague-infected rat had been found and the guinea-pig developed plague: D, houses not proved to be plague infected. It is seen that in the houses of groups A and C, especially in A, the number of fleas taken was very much greater than in the houses of groups B and D.

TABLE XXIX.

Showing the results of the flea census in houses, classified according to their being proved plague infected or not.

	Nature of houses	No. of houses	No. of fleas	Average No. of fleas per house
1.	Total houses	49	713	14·5
2.	A. Houses which were infective for guinea-pigs	9	376	42
3.	B. Houses which were not infective for guinea-pigs	40	337	8·4
4.	C. Houses which were proved plague infected	18	467	26
5.	D. Houses not proved to be plague infected	31	246	8

Summary.

In 18 % of instances guinea-pigs allowed to run free in plague houses developed the disease and died.

Three times as many fleas were caught in plague-infected as in not plague-infected houses, and five times as many in houses which proved infective to guinea-pigs as in those not infective.

Group II.

Series II.

Experiments with fleas caught on plague-infected rats found in houses.

In this series of experiments, only six in number, fleas, taken on rats which were proved by post-mortem and bacteriological examination to be plague infected, were transferred to healthy guinea-pigs in flea-proof cages in the laboratory. The rats were either found dead or trapped in a dying condition in houses in the villages. The details of these experiments are given in Table XXX. From this table it is seen that three out of six of the guinea-pigs to which the fleas were transferred died of plague.

TABLE XXX.

Experiments with fleas caught on plague-infected rats found in houses.

Serial No.	Date	Address	Number of fleas	Species and number of animals on which fleas were fed	Number which died of plague	Remarks
1	26/2/06	163 Dhand	83	guinea-gig 1	1	83 fleas removed from two rats caught in one trap. Both rats died soon after arrival at the laboratory, only one proved to be plague infected
2	5/3/06	24 Dhand	4	guinea-pig 1	1	Fleas obtained from one dead plague rat found in a bhoosa store
3	6/3/06	178 Dhand	30	guinea-pig 1	1	Fleas obtained from one dead plague rat found in a godown of this house
4	31/3/06	137 Dhand	3	guinea-pig 1	—	Fleas obtained from one dead plague rat found in a bhoosa store
5	2/4/06	122 Kasel	176	guinea-pig 1	—	Fleas obtained from one dead plague rat found in this shop
6	9/4/06	119 Kasel	48	guinea-pig 1	—	Fleas obtained from one dead plague rat found in this house

Series III.

Experiments with fleas caught on guinea-pigs and rats which had been left for some hours in plague houses.

In this series of experiments fleas were caught either on guinea-pigs or on rats, which had been placed in plague houses for about eighteen hours. The fleas were brought to the laboratory in test-tubes. They were then immediately put on a fresh guinea-pig or rat in a flea-proof cage. The details of these observations are set forth in Table XXXI, which shows that in seven out of 25 experiments the animals, always guinea-pigs, to which the fleas were transferred, died of plague. The distribution of the primary bubo in these seven guinea-pigs was as follows: 1 no bubo; 4 in the neck alone; and 2 in the groin alone.

Summary.

In 10 out of 31 experiments fleas caught on rats and guinea-pigs in plague houses conveyed plague to fresh animals in the laboratory.

GROUP III.

Series IV.

Experiments with animals in cages, unprotected and protected with fine wire gauze, placed in plague houses.

In this series a curtain of fine metallic gauze, such as is used for filtering petrol, was used to prevent the access of fleas. In the first report we have already described and figured the cages which were employed for this purpose in Bombay. Cages of exactly the same pattern were used in the present series of experiments.

The details of the experiments are set forth in Table XXXII. From this table it is seen that twenty-one experiments were made, guinea-pigs being the only animals used.

Only on one occasion were any fleas got on the protected animals, and then only a single one. On the unprotected animals on seventeen occasions fleas were taken, as many as seventy-five being caught on one occasion. None of the protected animals contracted plague, while four (19 %) of the unprotected guinea-pigs died of the disease. Every one of these guinea-pigs had a bubo in the neck, and in the case of two of them there was also a bubo in the groin.

TABLE XXXI.

Experiments with fleas caught on guinea-pigs and rats which had been left for a night in plague houses.

Serial No	Date	Address	Number of fleas	Species and number of animals on which fleas were fed	Number which died of plague	Remarks
1	30/1/06	347 Dhand	70	Guinea-pig 1	—	Vide Nos. 1 and 2, Table XXVIII
2	9/2/06	352 Dhand	16	Guinea-pig 1	—	Vide No. 5, Table XXVIII
3	9/2/06	349 Dhand	5	Guinea-pig 1	—	Vide No. 6, Table XXVIII
4	10/2/06	350 Dhand	16	Guinea-pig 1	1	Vide No. 7, Table XXVIII
5	23/2/06	,,	26	Rat 1	—	These fleas were got from a rat which was kept in a trap in back room of house No. 350 in which a plague rat was found on 9/2/06
6	23/2/06	349 Dhand	178	Rat 1	—	These fleas were got from 2 rats kept in a trap in the house
7	25/2/06	439 Dhand	2	Guinea-pig 1	—	Vide No. 15, Table XXVIII
8	16/3/06	746 Kasel	28	Guinea-pig 1	—	Vide No. 17, Table XXVIII
9	24/3/06	159 Dhand	26	Guinea-pig 1	—	Vide No. 18, Table XXVIII
10	29/3/06	402 Dhand	9	Guinea-pig 1	1	Vide No. 20, Table XXVIII
11	31/3/06	39 Dhand	108	Guinea-pig 1	1	Vide No. 21, Table XXVIII
12	1/4/06	15 Dhand	25	Guinea-pig 1	1	Vide No. 22, Table XXVIII
13	3/4/06	122 Kasel	9	Guinea-pig 1	—	Vide No. 23, Table XXVIII
14	4/4/06	114 Kasel	70	Rat 1	1	Vide No. 24, Table XXVIII Vide No. 27, Table XXVIII
15	10/4/06	225 Dhand	14	Guinea-pig 1	1	The fleas were got from 1 rat and 1 guinea-pig kept for a night in the house. Neither of these animals died of plague.
16	12/4/06	622 Dhand	5	Guinea-pig 1	—	Vide No. 28, Table XXVIII
17	17/4/06	1010 Kasel	60	Guinea-pig 1	—	Vide No. 30, Table XXVIII Vide No. 32, Table XXVIII
18	21/4/06	583 Dhand	11	Guinea-pig 1	1	The fleas were caught on a guinea-pig which died under chloroform during removal of fleas
19	23/4/06	1158 Kasel	9	Rat 1	—	Vide No. 33, Table XXVIII
20	25/4/06	220 Dhand	100	Rat 1	—	Vide No. 35, Table XXVIII
21	4/5/06	387 Dhand	30	Guinea-pig 1	—	Vide No. 39, Table XXVIII
22	16/6/06	1147 Kasel	2	Guinea-pig 1	—	Vide No. 42, Table XXVIII
23	16/6/06	745 Kasel	4	Guinea-pig 1	—	Vide No. 43, Table XXVIII
24	17/6/06	270 Kasel	2	Guinea-pig 1	—	Vide No. 44, Table XXVIII
25	25/6/06	667 Kasel	5	Guinea-pig 1	—	Vide No. 46, Table XXVIII

TABLE XXXII.

Experiments with animals in protected and unprotected cages placed in plague houses.

Serial No.	Date	Address	Species of animals used	Number of fleas found on animals		Fate of animals		Remarks
				Protected	Unprotected	Protected	Unprotected	
1	20/4/06	248 Kasel	Guinea-pig	—	6	Survived	Survived	Dead plague rat found on 20/4/06
2	21/4/06	784 ,,	,,	—	1	,,	,,	Dead plague rats on 19/4 & 20/4/06
3	21/4/06	782 ,,	,,	—	75	,,	,,	Dead plague rat on 21/4/06
4	22/4/06	779 ,,	,,	1	12	,,	,,	Dead plague rat on 22/4/06
5	30/4/06	769 ,,	,,	—	2	,,	Died of plague	Dead plague rats on 25/4/06, 30/4/06 & 1/5/06
6	3/5/06	807 ,,	,,	—	6	,,	Survived	Dead plague rats on 2/5/06 & 3/5/06
7	8/5/06	422 ,,	,,	—	32	,,	Died of plague	Three plague rats on 5/5/06 & two on 7/5/06
8	9/5/06	923 ,,	,,	—	6	,,	Survived	Dead plague rats on 9/5/06 & 11/5/06
9	9/5/06	980 ,,	,,	—	30	,,	Died of plague	Plague rats on 8/5/06, 10/5/06
10	14/5/06	256 ,,	,,	—	4	,,	Survived	Plague case on 11/5/06 Dead plague rat on 15/5/06
11	,,	920 ,,	,,	—	—	,,	,,	Dead plague rats on 13/5/06 & 15/5/06
12	,,	746 ,,	,,	—	—	,,	,,	Dead plague rat on 14/5/06
13	16/5/06	376 ,,	,,	—	4	,,	,,	One dead plague rat on 16/5/06 Two dead plague rats on 17/5/06 One dead plague rat on 18/5/06
14	,,	371 ,,	,,	—	2	,,	,,	Dead plague rat on 15/5/06
15	19/5/06	743 ,,	,,	—	4	,,	Died of plague	Plague rats on 11/5, 18/5, 19/5 and 20/5/06
16	,,	745 ,,	,,	—	—	,,	Survived	One dead plague rat on 16/5 Two dead plague rats on 17/5
17	25/5/06	199 ,,	,,	—	—	Died, not plague	,,	One case of plague on 17/5 Dead plague rat on 24/5
18	9/6/06	212 ,,	,,	—	1	Survived	,,	Dead plague rats on 31/5 & 7/6/06
19	15/6/06	615 ,,	,,	—	1	,,	,,	Dead plague rat on 15/6/06
20	,,	1036 ,,	,,	—	4	,,	,,	Dead plague rat on 15/6/06
21	26/6/06	700 ,,	,,	—	3	,,	,,	Dead plague rats on 23/6/06 & 26/6/06

Series V.

Experiments with animals in cages, one surrounded with "tanglefoot" the other not so protected, placed in plague houses.

Cages of exactly the same pattern as were used in the Bombay experiments and which have been already described and figured were employed for the present series. One of the animals instead of being protected from fleas by means of a metallic gauze curtain, was surrounded by an area spread with a sticky resinous preparation, called "tanglefoot," which in the case of the other animal was replaced by a layer of sand. By this contrivance it was expected that fleas, which were attempting to get at the animals, in the case of the "tanglefoot" cage would be caught on this material, but that in the case of the sand cage, with no such barrier to cross, would be able to get at the animal itself. At the same time both animals were protected from soil and contact infection and were equally exposed to aerial infection. In Table XXXIII are set forth the results of these observations.

Only in the first few experiments was any attempt made to identify the species of fleas caught on the tanglefoot and to dissect these, in order to ascertain whether plague bacilli were present in the stomach contents or not. At this time the epizootic and epidemic in Kasel were at their height and the large amount of work which was entailed in their study left little or no time for experimental work. It will be seen, however, that of 156 fleas, the species of which were noted, 138 were rat fleas and only 18 cat fleas. Further, it will be seen from the table that out of 55 rat fleas dissected the stomach contents of three were found to contain plague-like bacilli. 217 fleas which were neither identified nor dissected were also caught on the tangle-foot.

As regards the number of fleas taken on the animals themselves, only on three occasions out of 30 experiments were any fleas found on the animals which were surrounded with tanglefoot and on each of these animals only one flea was taken. As regards the sand cages, a total of 54 fleas were caught off 17 animals, while no fleas were found on the remaining 13 guinea-pigs.

None of the animals which were surrounded by tanglefoot developed plague; two of those left unprotected contracted the disease.

Summary.

In houses in which plague-infected rats had been found animals protected and unprotected from fleas were placed. In 51 experiments

TABLE XXXIII.

Experiments with animals in cages, one surrounded with tangle-foot, the other not so protected, placed in plague houses.

Serial No.	Date	Address	Species of animal used	Species and number of fleas caught on tangle-foot	Species and number of fleas caught on tangle-foot found infected with *B. pestis*	Number of fleas caught on animals		Fate of animals		Remarks
						Tangle-foot	Non-Tangle-foot	Tangle-foot	Non-Tangle-foot	
1	20/4/06	960 Kasel	Guinea-pig	2 rat, 7 cat	5 dissected, none infected	—	—	survived	died under chloroform	Dead plague rat on 19/4/06
2	,,	111 ,,	,,	5 rat	5 rat – 2	—	2	,,	survived	Dead plague rats on 18/4/06 & 19/4/06
3	23/4/06	969 ,,	,,	66 rat	40 rat – 1	1	4	,,	,,	Dead plague rat on 23/4/06
4	30/4/06	823 ,,	,,	10 rat, 4 cat	5 rat – 0	—	2	died under chloroform	,,	Dead plague rat on 30/4/06
5	3/5/06	393 ,,	,,	6 rat, 3 cat	none dissected	1	—	survived	,,	Dead plague rat on 2/5/06
6	,,	390 ,,	,,	19 rat, 3 cat	,,	1	10	,,	,,	Plague rats on 27/4, 29/4, 1/5 (2) & 2/5/06
7	5/5/06	422 ,,	,,	30 rat, 1 cat	,,	—	2	,,	,,	Vide No. 7, Table XXXII
8	8/5/06	51 ,,	,,	—	—	—	—	,,	chloroform on 24/5, plague	6 plague rats between 4/5 & 7/5/06
9	,,	421 ,,	,,	3 (species not noted)	none dissected	—	—	,,	survived	Dead plague rat on 8/5/06
10	10/5/06	790 ,,	,,	7 (species not noted)	,,	—	6	,,	died on 13/5/06, not plague	Dead plague rat on 7/5/06 Live plague rat on 9/5/06
11	14/5/06	181 ,,	,,	19 (species not noted)	,,	—	—	,,	survived	1 dead plague rat on 13/5/06 2 dead plague rats on 14/5/06
12	,,	395 ,,	,,	114, mostly rat	,,	—	12	,,	died of plague 18/5	Dead plague rats on 9/5 & 13/5/06
13	16/5/06	375 ,,	,,	2 (species not noted)	,,	—	—	,,	survived	4 dead plague rats on 14/5/06
14	,,	373 ,,	,,	6 (species not noted)	,,	—	2	,,	,,	3 dead plague rats on 15/5/06
15	19/5/06	376 ,,	,,	1 ,,	,,	—	—	,,	,,	4 dead plague rats between 16/5 & 18/5
16	21/5/06	371 ,,	,,	19 ,,	,,	—	—	,,	,,	Dead plague rats on 15/5 & 20/5
17	,,	712 ,,	,,	9 ,,	,,	—	1	,,	,,	Plague rats on 20/5, 21/5 & 22/5
18	23/5/06	232 ,,	,,	13 ,,	,,	—	1	,,	,,	Plague rat on 23/5/06
19	,,	224 ,,	,,	1 ,,	,,	—	1	,,	,,	Plague rat on 22/5/06
20	25/5/06	375 ,,	,,	8 ,,	,,	—	—	,,	,,	Vide No. 13 supra Putrid rat on 24/5/06
21	25/5/06	373 ,,	,,	7 ,,	,,	—	3	,,	,,	Vide No. 14 supra Dead plague rat on 20/5/06
22	27/5/06	355 ,,	,,	2 ,,	,,	—	—	,,	,,	Dead plague rat on 27/5/06
23	28/5/06	745 ,,	,,	—	,,	—	—	,,	,,	1 dead plague rat on 16/5/06 2 dead plague rats on 17/5/06 1 dead plague rat on 28/5/06
24	31/5/06	734 ,,	,,	1 (species not noted)	,,	—	1	,,	,,	Dead plague rat on 30/5/06
25	31/5/06	728 ,,	,,	3 ,,	,,	—	—	,,	,,	2 dead plague rats on 30/5/06
26	2/6/06	223 ,,	,,	2 ,,	,,	—	1	,,	,,	Dead plague rat on 1/6/06
27	9/6/06	693 ,,	,,	—	,,	—	2	,,	,,	Dead plague rat on 7/6/06
28	9/6/06	321 ,,	,,	—	,,	—	1	,,	,,	Putrid rat on 8/6/06
29	12/6/06	485 ,,	,,	—	,,	—	—	,,	,,	Dead plague rat on 10/6/06
30	12/6/06	355 ,,	,,	—	,,	—	—	,,	,,	Vide No. 22 supra Dead plague rat on 11/6/06

fleas were found on the protected animals four times and on the unprotected 34 times; six of the unprotected animals died of plague but none of the protected guinea-pigs.

It is unnecessary to enter into the conclusions which may be drawn from these observations. We have already set them forth in detail in the two papers which have reference to the similar series of observations made in Bombay. It is, however, important to note that exactly the same results were obtained in these Punjab villages as in Bombay.

VI. THE QUESTION WHETHER PLAGUE TENDS TO RECUR IN HOUSES IN SUCCESSIVE EPIDEMICS.

An attempt was made to determine whether houses, which were infected in one epidemic were especially liable to be again infected in any subsequent epidemic.

We had first to find out particulars of the incidence of plague (*i.e.* plague cases) in houses during previous epidemics.

A record of deaths from plague in previous epidemics existed and it was only necessary to determine accurately the houses in which these deaths had occurred. The information with regard to non-fatal cases, of which no records existed, was obtained by inquiry at each house, whether any of the family had recovered from plague and if so during which epidemic. Only cases in which a definite history of fever and bubo was given were taken as having had plague.

From the information derived from these two sources lists of the houses in which plague cases had occurred were prepared for each epidemic. The total number of occupied houses and the number of houses infected in each epidemic for both Dhand and Kasel is shown in Table XXXIV.

TABLE XXXIV.

Showing the total number of occupied houses and the number of houses infected in each epidemic.

Village	Total No. of occupied houses	No. of houses infected in first epidemic	No. of houses infected in second epidemic	No. of houses infected in third epidemic	No. of houses infected in fourth epidemic
Dhand	418	101	198	40	26
Kasel	806	308	252	230	67

Table XXXV shows the actual numbers of houses which were infected in one epidemic only, in any two, in any three and in all four

epidemics; while Table XXXVI gives the figures, which have been calculated from the data in Table XXXIV, showing the probable number of houses which would have been infected in one, two, three, and four epidemics, on the assumption that the houses were equally liable to infection throughout all four epidemics.

TABLE XXXV.

Showing the actual number of houses in Kasel and in Dhand which were infected (i.e. which furnished plague cases) in one, two, three and four epidemics.

Village	No. of houses infected			
	In one epidemic only	In any two epidemics	In any three epidemics	In all four epidemics
Dhand	208	65	9	0
Kasel	383	169	43	2

TABLE XXXVI.

Showing the calculated probable number of houses which would have been infected in one, two, three and four epidemics, if all houses were equally liable to infection throughout all four epidemics.

Village	No. of houses infected			
	In one epidemic only	In any two epidemics	In any three epidemics	In all four epidemics
Dhand	201	73	8	0·3
Kasel	393	162	40	2

The close correspondence between the actual and calculated figures suggests that the assumption on which the latter figures were worked out is a legitimate one, or, in other words, that plague showed no tendency to recur in houses during successive epidemics.