

Reports and papers on suspected cases of human plague in East Suffolk and on an epizootic of plague in rodents.

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REPORTS
TO THE
LOCAL GOVERNMENT BOARD
ON
PUBLIC HEALTH AND MEDICAL
SUBJECTS.

(NEW SERIES No. 52.)

Reports and Papers on suspected cases of human plague in East Suffolk and on an epizootic of plague in rodents:—

- I. Report on suspected pneumonic and bubonic plague in East Suffolk and on the prevalence of plague in rodents in Suffolk and Essex: by Dr. Bulstrode.
- II. Observations on rat plague in East Suffolk: by Drs. Martin and Rowland.
- III. Report on the pathological and bacteriological examination of rodents: by Drs. Petrie and Macalister.



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TO THE RIGHT HONOURABLE JOHN BURNS, M.P.,
PRESIDENT OF THE LOCAL GOVERNMENT BOARD.

SIR,

I HAVE the honour to submit to you reports and papers on suspected cases of human plague in East Suffolk, and on an epizootic of plague in rodents which has occurred in the same county.

These reports set out in detail the epidemiological facts of the outbreak, and the action taken by the Board to deal with it. In submitting them, the following brief outline of the course of events is first presented.

HUMAN CASES OF ILLNESS.

On October 2nd, 1910, Dr. Sleigh, the medical officer of health of the Samford rural district, notified to the Board four cases of "pneumonic plague" at Freston. Dr. Bulstrode was instructed to investigate the circumstances and to tender such advice as might be required. The results of the inquiry into the character of these four fatal cases of human illness are fully set out in Dr. Bulstrode's report.

The bacteriological diagnosis of these cases was not subsequently fully confirmed by inoculation tests; but having regard to subsequent events, it is a reasonable inference that they may have been plague; and there is the further possibility that two previous limited outbreaks of illness in the same part of East Suffolk may also have been plague (*see* pages 31 and 38).

EXTENT OF PLAGUE IN RODENTS.

As the inquiry proceeded it became clear that rodents were involved. Rats and hares found dead and examined by Dr. Klein, the Board's bacteriologist for this work, were pronounced, after confirmation by inoculation, to have had plague. At first the infected rodents, which were chiefly rats, were found only in that portion of the Samford rural district which lies between the rivers Orwell and Stour (*see* map opposite p. vi.). The further investigation which was rapidly made, soon showed, however, that the rats over a somewhat extensive area were infected with plague. Towards the middle of November the continuous examination of rats made it clear that there were plague-infected rats in many parts of the Samford and Woodbridge rural districts and in the adjoining urban districts. A single infected hare had also been found in the Cosford rural district, and a second one in the Tendring rural district.

Subsequent examination of rats, hares, and other rodents by Dr. Klein has not revealed the presence of infected rodents in other districts. Systematic inquiry for dead rats has been made; bacteriological examination of any rats regarded as suspicious has been freely undertaken; and every endeavour has been made to localise the epizootic.

When apparent localisation was established, the Board undertook a comprehensive scheme of delimitation by the examination of rats in all the districts within a belt surrounding the known infected areas. This scheme is further mentioned on p. v. It suffices to state here that no new infected area was discovered.

The following chronological statement indicates the course of events:—

October 2nd. Four deaths at Freston reported to the Board.
 „ 3rd. The Board's inspector visited the locality.
 „ 8th. The first infected rat and hare secured for examination were examined by the Board's bacteriologist.

October to November 10th. Infected rats and a few hares discovered in eight sanitary districts.

November 10th to date. No new infected districts discovered.*

FURTHER ACTION BY THE BOARD.

(a) *Infected Districts.*

From the first it was realised that grave significance attached to the presence of a focus of plague in rodents in East Suffolk, and that no efforts should be spared in coping with the situation.

The most urgent step was that of warning and stimulating to activity the local authorities and their officers in the known infected districts. Two inspectors, Drs. Fletcher and Reece, in addition to Dr. Bulstrode, took up this work, conferring with and advising also the officers of local authorities outside the known infected area. Every sanitary district in the administrative counties of East and West Suffolk and in the north-east portion of Essex was visited, as well as a few districts in Cambridgeshire and Norfolk; and the necessary precautions were fully discussed with all the officers concerned. These are set out in full in Dr. Bulstrode's report.

(b) *England and Wales.*

In order that every sanitary authority in England and Wales might be put on the alert to detect any human or rodent cases of plague, the Board sent out a circular letter covering a Memorandum on Plague, by the Medical Officer of the Board (*see pp. 71 to 77*); and attention was drawn to the fact that the Board were prepared to continue their practice of many years to examine material from human beings or from rodents, forwarded by medical officers of health, which might be regarded with suspicion (*see p. 78*).

A special circular letter (*see p. 79*) was also sent to the principal port sanitary authorities advising the examination of rats with a view to ascertaining whether any were infected with plague.

* No district has been regarded as infected until the presence of plague infected rodents has been established by inoculation tests on animals. Experience has shown that post-mortem examination of suspected material followed by microscopical and cultural tests does not ordinarily suffice to establish a definite diagnosis of plague.

As the result of this action a number of rats have reached the Board from different parts of England and Wales. None of these have been found to be infected with plague.

ACTION BY THE EAST SUFFOLK COUNTY COUNCIL.

During his earlier visits Dr. Bulstrode pointed out the importance of the County Council making arrangements for the bacteriological examination of rats and for co-ordinating the work of the district councils within the administrative county. At that time the County Council had not appointed a medical officer of health under section 17 of the Local Government Act, 1888, but they at once engaged temporarily Dr. H. Llewellyn Heath, D.P.H.; and the Public Health Committee of the County Council, advised by Dr. Heath, have done valuable work in organising measures throughout the county. A deputation from this Committee was received in London by the President of the Local Government Board, and points of difficulty discussed.

Dr. Heath has reported on the action taken by the County and District Councils, and extracts from his report are included in the Appendix (p. 80).

ACTION BY SANITARY AUTHORITIES.

The Board communicated with the Council of each affected district and arranged to be supplied with weekly reports of the action taken by each authority. A copy of the letter thus sent is given on page 68.

The degree of action taken by the different sanitary authorities in and around the infected area has varied. This action is set out in Dr. Bulstrode's report. In most districts good work has been done, especially in arranging measures for rat destruction. While public attention continued to be drawn to the outbreak, energetic measures were freely taken; but in some instances there has not been steady and persistent action on the part of the local authorities.

DESTRUCTION OF RATS.

Of the measures taken in the infected area, that of rat destruction has been the one carried out with the greatest degree of efficiency.

Advice as to rat destruction was always associated with the still more important counsel as to the need for preventing the access of rats under and into dwellings; and stress was laid on the importance of securing a diminution of rats by preventing their access to supplies of food.

Rats have been destroyed by professional rat-catchers, by shooting, by ferrets and dogs, and by poisons, bacterial and chemical. Landowners, farmers, gamekeepers, and many others have seconded the efforts of sanitary officials in this work; and enormous numbers of rats have been destroyed. Unfortunately, some owners and occupiers of property have not co-operated

with the rest of the public and with local authorities, and consequently in some localities rat destruction has not been uniformly practised.

The Board, as soon as it became known that rat destruction was not being carried out uniformly, issued an Order conferring power on local authorities to take measures for the destruction of rats, and making it the duty of a local authority, when a representation was made to it that its district was affected or threatened with plague, to take measures to destroy all rats within its district. The Order and circular which accompanied it are reprinted on pp. 68 and 69.

The complete destruction of rats in a district may be regarded as a counsel of perfection, but the thinning out of rats, if maintained, diminishes risk to mankind, apart from the incidental economic gain thus secured. The sparser the rat population, the less risk is there of spread of infection in rodents, or of its occasional transmission to man.

In the infected districts effort has not been so generally devoted to two lines of action, which are of equal importance to, if not of greater importance than, the direct destruction of rats. These are—action directed towards making each house rat-proof, so far as underground invasion is concerned, and action calculated to prevent the access of rats to corn stacks and to other supplies of food. It is probable that the number of rats in a district is conditioned by the amount of food available for them; and that the indirect attack on rats by starvation may be even more successful than direct attack by destruction. The only method likely to be completely successful is that which combines measures for direct destruction of rats with measures for preventing them from obtaining access to food supplies.

Should experience show that individual owners and occupiers refrain from helping local authorities in destroying rats on their premises, and in rendering their premises and food stores fairly safe against invasion by rats, the question will arise whether powers to compel such assistance should not be employed by local authorities.

DELIMINATION INVESTIGATION.

Early in December last, examination of rats from various districts had shown that the infection of rats by plague was practically limited to an area embracing the districts in the Samford and Woodbridge Unions. The importance of confirming this conclusion was obvious; and for this purpose a systematic examination of rats derived from a belt of country surrounding the known infected area was arranged. The rats thus examined were derived from sanitary areas in the following Unions:—Plomesgate, Blything, Hoxne, Hartismere, Stow, Thingoe, Sudbury, Lexden and Winstree, Colchester, Tendring, Halstead, Braintree, and Maldon. These areas, as will be seen from inspection of the map facing page vi., form a continuous belt around the infected districts.

The Board having obtained the necessary authority from the Treasury for the expenditure, the arrangements for collecting

and forwarding the rats were undertaken by Drs. Bulstrode, Fletcher, and Reece. The rats were sent to Ipswich, where they were received and particulars tabulated by Mr. C. J. Huddart on behalf of the Board. The examination of rats was entrusted to Drs. Petrie and Macalister, of the Lister Institute, and was carried out at a laboratory which had been gratuitously placed at the disposal of the Board by the Ipswich Town Council, and prepared for the purpose by Dr. Pringle, medical officer of health of that borough. The system of examination adopted consisted of a primary post-mortem examination of each rat. If any suspicious signs were visible, a bacteriological examination was made; and if this did not enable a negative diagnosis as regards plague to be made, the examination was remitted to the Lister Institute for more complete experiments.

The report by Drs. Petrie and MacAlister on their laboratory work is given on page 56; and on page 86 will be found a tabulated summary of the number and sources of rats examined, which has been prepared from Mr. Huddart's records. This tabulated summary should be considered in connection with the map facing this page.

Altogether 6,071 rats were received from 22 urban districts, and from 301 parishes in 15 rural districts. Of this number 6,017 were declared negative on post-mortem examination, 43 on further cultural tests at Ipswich, and 8 after further examination at the Lister Institute. The remaining 3 rats, which did not manifest very suspicious features on post-mortem examination, yielded on culture an organism similar to *bacillus pestis*. This bacillus on further examination (*see* page 61) is regarded as the *bacillus pseudo-tuberculosis rodentium*.

The diagrammatic map facing this page shows clearly the area under observation in this delimiting experiment, and the position of the parishes from which rats were obtained for examination.

SCIENTIFIC WORK ON RAT FLEAS.

A report is included (pages 41 to 55) by Drs. C. J. Martin and Sydney Rowland, of the Lister Institute, on epizootic plague in East Anglia, with special reference to the fleas infesting rodents. As is well known, the chief flea infesting the ordinary black rat of India is the *Xenopsylla cheopis*, which readily bites man. No black rats were found in Suffolk; and the examination of the brown rats showed that they are infested with about equal numbers of two species of fleas, *Ceratophyllus fasciatus* and *Ctenophthalmus agyrtes*. Of these, the former readily bites man; and Dr. Martin found the *bacillus pestis* in the stomachs of some fleas of this species removed from plague-infected rats.

The second kind of flea does not readily bite man. It is noteworthy also that the number of fleas was small. From 568 rats examined, only 584 fleas were obtained.

Omitting the *Ctenophthalmus agyrtes*, which does not seem to bite man, the effective prevalence in East Anglia is only about one flea to two rats. This, as Dr. Martin points out, "is an infestation which was not found sufficient to give rise to a human



epidemic in India, notwithstanding the vastly greater accessibility of mankind for rat fleas" (page 48). The examination was, however, made in November, and it cannot be stated until after next summer whether the same comparative freedom of English rats from fleas holds good during the warmer months of the year.

THE SOURCE OF THE EAST ANGLIAN EPIZOOTIC.

In his report, Dr. Bulstrode gives in detail all the available evidence as to the channels by which plague may have been introduced among the rodent population in the neighbourhood of the rivers Stour and Orwell. It is, I think, highly probable that it has been introduced by means of infected rats imported with foreign grain coming from plague-infected countries. No other instance of spread of plague from ship-rats beyond the limits of a port or landing place has been known to occur in this country, with the possible exception of Glasgow. This fact, considered in relation with the vast volume of the shipping trade between the United Kingdom and plague-infected countries, is reassuring; and shows that the precautions taken in this respect have, in the main, sufficed for practical requirements. Had any other importations of rodent plague been successful in producing inland foci of plague infection, there is little doubt that the resultant excessive mortality among rats would ere this have been discovered. This is especially true, as regards the period since the discovery of infected rats in Suffolk.

The examination of rats, which has been made on a large scale in some of our largest ports, has failed to discover any rats infected with plague, except on or in connection with ships arriving from abroad. These facts do not indicate any need for more stringent regulations for ships than those contained in the International Sanitary Convention of Paris, 1903, to the provisions of which this country has agreed.

As regards the precautionary measures taken, under the Board's Orders, against rats in our ports, the Board, from time to time, ascertain by "Port Sanitary Survey," conducted by their medical inspectors, the manner in which Port Sanitary Authorities secure the execution of these measures. Such a survey is in progress at the present time.

THE POSSIBILITIES OF FURTHER PLAGUE IN EAST ANGLIA.

The evidence appears to indicate that rat plague has been present for several years in East Suffolk. Nevertheless, during that time only three very limited outbreaks of probable human plague have occurred, showing that under the conditions there existent, human infection is an exceptional and, as it were, an accidental phenomenon. As is well known, the possibilities of spread of plague from rats to man are much smaller in this country than in India. We have the brown and not the black rat; the brown rat is not a domestic animal; its fleas, so far as present information extends, are less numerous than those of the black rat, and not more than half of them in investigations so far undertaken are of a kind that bites man; and most houses are not rat-infested.

Bubonic plague, as is well known, spreads through the intermediation of fleas. Pneumonic plague, however, spreads easily from person to person, and in two of the outbreaks of probable human plague in Suffolk, the attacks were chiefly pneumonic in type. These human cases occurred under conditions of domestic uncleanness; and given the infection of the first patient by rats' fleas to such an extent as to determine a septicæmic or pneumonic attack, infection may spread directly from person to person, or indirectly by means of the human fleas, which infest houses under uncleanly conditions. Such possibilities represent the chief danger of spread of plague among human beings. Apart from improvement of domestic sanitation, which is a valuable safeguard, the most important precaution is that all cases of obscure disease simulating influenza or "blood poisoning," and all cases of pneumonia in a suspected district should be regarded as being possibly plague, that means should be taken for obtaining a bacteriological diagnosis, and that effectual isolation should be secured pending the completion of this test. A considerable outbreak of human plague might be anticipated if such failure to recognise early cases occurred in a district in which the conditions favoured spread by direct infection from patient to patient, or by indirect infection by means of fleas.

The lines of action required for exterminating rat plague are set out in my memorandum, which is reprinted on pages 71-77. During the remainder of this year the Board's extended investigations will enable it to be said whether the foci of rat plague still continue, and will be made the occasion for further vigorous action against rats if infected districts are discovered.

I am, Sir,

Your obedient Servant,

ARTHUR NEWSHOLME,
Medical Officer.

May, 1910.

I.

Report to the Local Government Board upon the Occurrence in the Autumn of 1910 of Four Deaths at Freston near Ipswich, from a rapidly fatal and infectious malady diagnosed as Pneumonic Plague, and upon the Prevalence of Plague in Rodents in Suffolk and Essex. Together with a report upon two localised outbreaks of disease in East Suffolk in 1909-10 and 1906-7 which may have been instances of Bubonic and Pneumonic Plague respectively; by H. Timbrell Bulstrode, M.A., M.D.

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PART I.

Introductory Remarks.

On the afternoon of October 2nd, 1910, the Board received information from Dr. Sleight, medical officer of health of the Samford Rural District, relative to the death at Freston in that district of four persons from what was regarded locally as pneumonic plague, under circumstances which pointed to the conclusion that the disease had spread from person to person by infection. The medical officer of health added that the source of the disease remained a mystery, the patient first attacked not having been out of the district, and there being no evidence to indicate that infection had been introduced into the district from without.

It had been observed, he stated, that a great many rats were dying in the neighbourhood, a circumstance which he thought might be explained by the custom which obtained among the farmers of laying down rat poison at that time of year. All persons who had been in contact with the patients were being kept under observation, and all infected premises and articles had been disinfected.

Upon receipt of this communication I was instructed to visit the locality to make inquiries into the outbreak. This I did early on the following morning (October 3rd), and the investigation involved, together with the subsequent developments, occupied the whole of my time for the next three months.

Topography and Circumstances of the Invaded Area.

The accompanying map (which faces p. 40) will serve to show that the eastern portion of the Samford Rural District in which these occurrences took place forms in effect a peninsula between the estuaries of the Orwell and the Stour, the base of the peninsula, if so it may be termed, being the Great Eastern Railway line between Ipswich and Manningtree.

This topographical circumstance is of importance, since it means that this portion of the Samford Rural District is in a measure shut off by the Orwell on the north and east and by the Stour on the south.

The remainder of the administrative district extends some miles inland, its total length from east to west being about 15 miles, and its greatest width from north to south about 9 miles.

At its north-western extremity the district abuts for some three miles upon the county borough of Ipswich. The house first invaded by the disease (*see A on map*) was the central one of a row of three cottages known as "Latimer Cottages," which are situated a few yards back from the Holbrook Road, at a point about a mile to the south-east of its junction with the road to Chelmondiston and Shotley.

These cottages are distant about 4 miles from Ipswich, 3 from Chelmondiston, and $1\frac{1}{2}$ in a direct line from the estuary of the Orwell.

Ipswich, a county borough with some 75,000 inhabitants, is a port at which a large number of grain-laden vessels from foreign

ports arrive; and at Buttermen's Bay, near Chelmondiston (*see* I on map), large vessels laden with grain (mainly from North and South America) which, owing to their deep draft are unable to proceed direct to Ipswich Docks, are lightened, the grain being taken to Ipswich, or occasionally elsewhere, and the vessels themselves proceeding to Ipswich when their draft has been sufficiently reduced.

The Samford district is a thinly-populated area, the inhabitants of which are almost entirely engaged in agriculture, in connection with which industry large quantities of manure from London are introduced by barges into certain portions of the district.

The three cottages, of which the central one was invaded, are ordinary four-roomed dwellings; all three, together with a detached house to the north, being supplied with water from a common pump well, obviously liable to pollution from an adjoining pond, and each is served by a separate privy-vault. Each house has a garden attached to it.

HISTORY OF THE ILLNESS.

The personnel of the invaded house was at the time of the outbreak as follows:—

- *G. C. (the father), aged 57, a labourer working on an adjoining farm.
 - *F. C. (the mother), aged 40.
 - E. G., aged 14
 - F. G. aged 13
 - *A. G., aged 9
 - E. G., aged 7
- } Children of Mrs. C. by a former husband, Mr. G.

In addition there were, but not living at home—

Alice, aged 16, a girl in service in a neighbouring village.

Alfred, aged 18, a soldier.

The family had a few months previously moved into the cottage from Ipswich.

The attacks took place in the following order:—

Name.	Age.	Sex.	Onset of Disease.	Date of Death.	Date of Burial.
Latimer Cottages. { A. G. ...	9	F	Sept. 12, 1910	Sept. 16	Sept. 20
{ F. C. ...	40	F	Sept. 21, 1910	Sept. 23	Sept. 26
{ G. C. ...	57	M	Sept. 26, 1910	Sept. 29	Sept. 30
A. M. P. ...	43	F	Sept. 26, 1910	Sept. 29	Sept. 30

The latter patient lived in one of a group of two cottages about a quarter of a mile to the north of Latimer Cottages (*see* B on map), and she had nursed F. C. at the first invaded house on the night of September 23rd. The personnel of the house in which A. M. P. lived comprised, in addition to herself, her husband and six children.

Symptoms and Physical Signs in the Several Cases.

For my information relative to the cases I am indebted to notes from Dr. Carey and Dr. Sleigh, one or other of whom attended the cases, to Dr. Herbert Brown, whose assistance was sought in consultation, and to Dr. Heath, who carried out the bacteriological investigations, and the accounts which follow are based partly upon the notes and information thus furnished me and partly upon two papers contributed to the *British Medical Journal*.*

The child, A. G., aged 9, who was the first inmate to be attacked had some eight days previously returned from a cottage at Rence Park Farm, Harkstead, where she had been staying with relatives. This farm is situated in an isolated position near the middle of the Samford peninsula, about midway between the villages of Harkstead and Erwardon, but a little to the north thereof (*see map*).

This child was taken ill on September 12th with vomiting, and when seen next day by Dr. Carey, of Holbrook, she had a temperature of 105° .

No dulness was detected over the lungs and there was no cough; breathing was then normal. Next day the child's general condition appeared unchanged, but on the following day, September 15th, râles were detected over the base of both lungs and the breathing was accelerated. During the night the child coughed up some blood and suffered from diarrhoea and vomiting. There was also some delirium.

The child died on the morning of September 16th, the temperature having throughout the illness maintained a level of about 105° . Death was certified as due to "Gastric Catarrh and Pneumonia."

Mrs. C. (the mother), aged 40, who nursed the foregoing case, was taken ill on the night of Wednesday, September 21st, with headache and nausea, and when seen by Dr. Carey on the afternoon of the following day she had a temperature of nearly 105° , with crepitation at the base of both lungs, and during the night there was much vomiting and diarrhoea.

On the following morning, September 23rd, her breathing was very rapid, laboured, and gasping, and her pulse imperceptible. She died the same day, the cause of death being recorded as "Septic Pneumonia."

Some sputum from this case was collected for bacteriological examination by Dr. Herbert Brown, of Ipswich, who was asked by Dr. Carey to see the case. This sputum, which did not resemble pneumonic sputum, was brownish in colour and presented the appearance of being tinged with Anchovy sauce. It was examined by Dr. Heath, bacteriologist to the Ipswich and East Suffolk Hospital, who found in it pneumococci and gram-negative diplobacilli in large numbers.

* (a) Four cases of Pneumonic Plague, by H. P. Sleigh, M.D.; (b) the Recent Plague Cases in Suffolk, by Herbert H. Brown, M.D., F.R.C.S., *British Medical Journal*, Nov. 12, 1910.

G. C., the father, aged 57, was taken ill on September 26th, on which day he nevertheless attended his wife's funeral. On the following morning his temperature was 103° and he complained of headache and a "cold." At 3 p.m. his temperature was 104° .

On September 28th the patient was seen by Dr. Heath, who obtained some blood for examination, and on the same day at Dr. Carey's request he was seen by Dr. Brown, who found moist crepitant râles over the base of both lungs, but no dulness or bronchial breathing. There was slight cough and some expectoration, but no diarrhœa or vomiting. The temperature was 105° , pulse 120, and respiration 30-40.

On the following day, September 29th, the condition of the patient was very much the same, with a temperature of 104° to 105° —no delirium, vomiting, or diarrhœa. There was no loss of consciousness until a few minutes before death, which occurred at 7 p.m. on the same day.

Death was certified as due to "Influenza and Pneumonia."

A. M. P., aged 43, who, as already mentioned, lived a short distance away, nursed Mrs. C. on the night of September 22nd-23rd. She was taken ill on September 26th, and when seen by Dr. Sleigh on the morning of September 27th had a temperature of 101.2° , pulse 120, and respiration 36. She complained of headache, severe pain in the left back, and the left side of her face was very flushed. She lay on her right side, coughed very little, and there was no expectoration, delirium, diarrhœa, or vomiting. Temperature 103° to 104° .

She was seen by Dr. Brown at 11 a.m. on Wednesday, September 28th, when her breathing was about 50, laboured and rattling, her pulse 130, and her general aspect a bad one.

On the left side there was dulness all over the base of the lung, with bronchial breathing and moist crepitant râles. There was also a somewhat similar condition at the extreme base of the right lung.

Dr. Brown aspirated the lung and obtained about six drops of serum for culture.

At night her temperature was 105.6 and she complained of severe pains over chest and back. She was vomiting incessantly and had constant diarrhœa until death supervened at 9.40 a.m. on Thursday, September 29th. There was no loss of consciousness and no delirium. Death was certified as due to "Influenza and Pneumonia."

Some Characteristics of the Illness.

In the first place, the anomalous nature of the attacks attracted attention. The disease could not be classified. The condition of the patients was more serious than the physical signs warranted, and the patients became rapidly worse without any clear evidence of corresponding lung involvement. The temperature was in the majority of cases out of proportion to the physical signs.

Although there was, Dr. Brown points out, definite evidence of lung congestion in every case, in only one instance, that of A. M. P., was there extensive pneumonic consolidation. Diarrhœa and vomiting was pronounced in three out of the four cases.

In other words, there was probably lobular pneumonia, which is such a characteristic feature of pneumonic plague, in two, if not three, out of the four cases.

There was, Dr. Sleigh observes, dark, blood-stained expectorations in every case, except that of A. M. P., but such expectoration was in no sense typical of lobar pneumonia.

The nervous system was but little involved, and there was only delirium in one instance. As regards the other cases, consciousness was retained until a few minutes before death.

The infectivity of the disease was obviously high, but, as regards this point, it has to be observed that more or less continuous and intimate association with the patient, and this by persons relatively ignorant of the importance of taking precautions, seems to have been necessary for infection. The two Ipswich nurses who, to their great credit, volunteered for service after the risks had been fully explained to them by Dr. Brown, escaped infection, as also did the district nurse and Mrs. C., the dead woman's sister.

The several medical men who were called in to see the cases, and who were brought, at least for a short time, into intimate contact with the patients escaped, as also did the rector of Freston, the Rev. C. Durrant, and his daughter, both of whom fearlessly ministered to the sick.

Moreover, in both of the invaded houses there were several persons—mostly children—who, before the nature of the disease was suspected, must have had opportunities, although, perhaps, minor and transient, of becoming infected, but who, nevertheless, remained well. Subsequently, however, these persons were isolated, first on the premises and later at the isolation hospital at Tattingstone.

As will be seen in Part III. of this report, a similar high infectivity characterised the outbreaks of illness at Shotley and Trimley.

As regards fatality-rate, that of the Freston outbreak was 100 per cent., *i.e.*, 4 cases and 4 deaths; while that of the two outbreaks of suspicious illness, described in detail later on, was almost equally high.

It may be added that a high fatality-rate is one of the characteristics of pneumonic plague, as is being exemplified in the outbreak of that disease in Manchuria.

The Bacteriological Findings.

As will be seen by the foregoing accounts of the clinical features of the Freston cases, and by the forms which the death certificates took in the first instance, the attending physicians were puzzled as to the precise nature of the malady.

Dr. Brown, therefore, determined to have recourse to bacteriological examination, and he submitted to Dr. Llewellyn Heath, honorary bacteriologist of the Ipswich and East Suffolk Hospital,

a specimen of sputum which he had obtained from the second Freston case (Mrs. C.). Dr. Heath, as the result of his examination of this material, discovered microscopically a gram-negative bacillus of which, however, he was unable to prepare a culture. But in connection with the third case (that of Mr. C.) he examined specimens of blood, obtained both by himself and Dr. Brown, as well as some lung juice procured by the latter from Mrs. P. (the 4th case). From all these Dr. Heath obtained, in bouillon and upon agar cultures, specimens, *inter alia*, of a gram-negative bacillus which he regarded both by its morphological and cultural characters as *Bacillus pestis*. He concluded, therefore, that the Freston cases were cases of pneumonic plague.

He at once proceeded to Cambridge and submitted to Professor Sims Woodhead slides made from the bouillon cultures, and also a film made direct from the lung juice. After examining these, Professor Sims Woodhead expressed the opinion that Dr. Heath was justified in his suspicions.

Dr. Heath also took with him six cultures, from several of which he had prepared slides which were afterwards submitted to Dr. Klein. Two of these were examined by Professor Simpson, who agreed with Dr. Heath that the appearances were consistent with plague. One of the bouillon cultures, which showed stalactite growths, was retained by Professor Woodhead, but the others were destroyed, and Dr. Heath thinks it improbable that he prepared a slide from this retained culture.

As the bacteriological findings were a matter of importance, I at once, after conferring with Dr. Heath and obtaining his full concurrence in the matter, proceeded to Cambridge to confer with Professor Sims Woodhead, who was good enough to lend me certain of the cultures for inoculation experiments by Dr. Klein, F.R.S. These inoculation experiments yielded negative results.

As, however, there were other cultures in Professor Woodhead's laboratory, I also secured them; but these, like the former, were negative as regards plague. The inoculation experiments here referred to were, as far as I am aware, the only ones which were made. Although the results were negative, it is highly probable, in view of the clinical symptoms of the Freston cases, and having regard to the subsequent discovery of undoubted rodent plague in the vicinity, that the Freston cases were cases of pneumonic plague.

Theories as to the origin of the Freston Outbreak.

The fact that all those who were attacked were dead and buried before the occurrence was brought to the notice of the Local Government Board rendered it impossible to obtain first-hand information from the patients themselves; and the swiftness of the seizure and subsequent death doubtless rendered it very difficult to cross-examine the patients during life, more especially as the nature of the malady was not at first suspected. This latter circumstance must also be held in view in considering the account of the physical symptoms and signs. Had plague been

suspected from the first fuller notes would doubtless have been made. The fact that the first child to be attacked had, as has already been said, recently been staying at a cottage on an isolated farm, led to inquiries being made concerning the child's movements while there.

The child arrived at this farm (occupied by a family named M——) from her home on August 28th, and left again on September 4th. She appeared in good health all the time, playing about in the harvest field and taking food to the men while they were at work. She often had her meals with them. During the week of her stay at the farm she only left it on the occasion when she went as far as Chelmondiston post office.

A child from London, Mrs. M.'s niece, had arrived the Friday before Bank-holiday, and she also was in good health all the time.

There had been no illness in the house, with the exception of one daughter who had died of pulmonary tuberculosis in May, 1910, after a prolonged illness. Inquiries were also made at the two other cottages on the farm, but no illness had occurred either amongst any of the two families or amongst animals, including rats, cats, fowls, rabbits, hares, or mice.

Some London manure had been spread on one of the more distant fields about four months ago, but none near the cottages.

But, under any circumstances, the fact that the child was not attacked until some eight days after her return to Latimer Cottages renders it extremely improbable, on the assumption that the disease was plague,* that she contracted this illness at the farm in question.

In so far as human sources are concerned, the origin of this child's illness must remain unexplained, as careful inquiries failed to elicit any connection with previous human disease of similar or suspicious nature either in the adjoining or neighbouring cottages or, in fact, anywhere in the district. But, as will be seen directly, the prevalence of plague amongst rats and certain other animals in the Samford peninsula, suggest opportunities for infection from this source which are significant.

The circumstance that two or three dead hares had been found in a neighbouring field and a dead cat upon the doorstep of an immediately adjoining cottage, two days previous to the child's illness, renders it far from improbable that infection may have been derived from one or other of these animals. The child may obviously have fondled the sick cat and derived infection from it or its fleas.

It was suggested by someone in the immediate locality that the child might possibly have found one of the dead hares and brought it home with the view of having it cooked. But no satisfactory evidence could be obtained in support of this view, although, if it were true, it is possible that the child may have contracted the disease from the hare, more especially if any

* The incubation period of plague is usually from 2-5 days, but at times it may be only a few hours.

attempt were made to skin the animal.* Fleas from the hare's body or, possibly, dried particles from its skin or hair might be thought of as the infecting agents.

A suggestion was also made that the family may have consumed one of these dead hares and that, if so, this might have accounted for the outbreak.

But apart from the recognised great difficulty of inducing plague by ingestion, the dates of onset in the several cases are opposed to a hypothesis of this nature, and the most that could be admitted, even if one of these hares had been eaten, of which there was no evidence, would be that an infected hare might have been responsible for the first case, and that the subsequent cases were caused by direct personal infection.

All four of the cases here in question were subsequently diagnosed as suffering from pneumonia—pneumonic plague—but the evidence, as regards the first case, seems to have pointed, the medical men who saw the case consider, to the fact that the pneumonia was a secondary and not a primary phenomenon, a conclusion which would fit in with the view that the first case may have derived its infection by flea inoculation. As has already been pointed out, the pneumonia which is associated with plague is usually a lobular and not a lobar pneumonia, and consequently the lungs do not present either on percussion or auscultation the characteristic signs of lobar pneumonia; in fact, one of the characteristic features of pneumonic plague is the circumstance that the general condition of the patient is much more serious than the physical condition of the lungs would seem to warrant. In this series of cases the several medical men who saw and examined them were puzzled as to their nature, and it was the anomalous character of the symptoms and physical signs which led to a bacteriological examination being made.

Evidence of Mortality amongst Rats and Hares.

Although the statement made in the report of medical officer of health as to excessive mortality amongst rats was subsequently reported to be without foundation, I heard in the course of my own inquiries allegations as to rat and hare mortality which called for further detailed inquiry.

For example, in addition to the report as to the dead hares and cats already referred to, I was told by an inmate of one of the three Latimer Cottages that rats had been seen in an obviously dying condition struggling across a road in the neighbourhood and only reaching the other side with the greatest difficulty.

*It is interesting to note in connection with the outbreak of pneumonic plague in Manchuria that report attributes the human illness to the hunting and killing of the "Tarbagan" or "Tarabagan" (*Arctomys bobac*), a rodent about 20 inches in length, which lives during the winter in burrows. Clemow records the case of a Cossack family into which the disease was apparently introduced by the capture and skinning of "Tarbagans." See "Plague in Siberia and Mongolia and the 'Tarbagan' (*Arctomys bobac*)," by Frank Clemow, M.D., D.P.H., *Journal of Tropical Hygiene*, February, 1900.

A telegram from Peking from the "Times" correspondent, on April 14, 1911, announced that Dr. Petrie of the Lister Institute had discovered 36 fleas of very large size on 12 marmots or "Tarbagans."

These circumstances seemed to point to one of two conclusions; either some common and fatal malady or the fairly widespread distribution of some animal poison such as one or other of the rat viruses.

In connection with this latter point I was informed by the district medical officer of health, Dr. Sleigh, that he had recently laid down some Danysz virus in the neighbourhood of his own grounds, which, of course, might offer some explanation of rat mortality thereabouts. But, to anticipate somewhat, it may be added that a dead hare found by Dr. Sleigh in his own garden was pronounced by Dr. Klein, after detailed bacteriological examination and animal inoculation, to have undoubtedly died of plague.

Moreover, I heard shortly afterwards from Mr. H. Jervis, of Freston House, who took a most active and helpful part in the investigation and control of the outbreak, that excessive mortality amongst rats had been observed as far away as Erwarton, which is 3-4 miles from the invaded houses, and this statement was also supported by other independent evidence. I heard also that rats had been observed to be dying on October 16th at Tattingstone, some two miles from the invaded house.

In connection with this subject I conferred with several persons likely from the nature of their occupation to be able to afford reliable information.

Mr. Gibbon, keeper to Mr. Jervis, had throughout a long experience never seen rats die in such numbers as in the autumn of 1910. He had heard of no dead hares. He and his men had especially noticed that the rats found dead had not wasted away as he alleged was the case with rats dead from the effects of one or another of the rat viruses.

Mr Bennett, who had for the last five years been head keeper to Mr. Berners, of Woolverstone Park (*see map*), stated that in 1906-7 rats were observed to be dying in large numbers in different parts of the estate. The rats at that time appeared to be in good condition when found dead and showed no sign of wasting, such as would be expected after a prolonged illness. He attributed it to the dry year.

At that time, 1906-7, a large number of dead rats had been observed at Shotley, Erwarton, Chelmondiston, and Harkstead, and practically the same condition of affairs had been noticed in the autumn of 1910.

In 1906-7 a large number of dead hares were found and some dead rabbits had also been seen. Mr. Bennett had used a large quantity of Liverpool virus over the whole estate in April, 1910, but none since.

He added, however, that with a virus, whether that of Danysz or Liverpool, the rats showed signs of wasting, whereas those found in 1910 were all well nourished. Testimony in the above sense was also furnished by the Rev. John Hervey, Rector of Shotley, and by the Rev. Hugh Berners, Rector of Harkstead.

Mr. Gasgoyne, one of the Woolverstone estate keepers, whom I consulted at the suggestion of Mr. Bennett, did not concur in

the view that, in so far as Shotley was concerned, there had been any undue mortality either amongst rats or hares.

But the balance of all the evidence clearly indicates in my view that, at any rate in certain localities in the Samford rural district, rats were dying in the autumn of 1910 in quite unusual numbers, and evidence of the same nature and equally clear is forthcoming from the Woodbridge rural district and from the Felixstowe urban district, both on the opposite side of the Orwell estuary.

The Bacteriological Evidence of Plague amongst Rodents.

It was some days before I was able to secure samples of dead rodents for bacteriological examination, but on October 8th Mr. Jervis, of Freston House, despatched to Dr. Klein a rat which had been found recently dead in Freston Wood (*see G on map*). Mr. Jervis added, in his letter, that there were many pheasants in the wood and that certainly no poison had been laid down near that spot.

The evidence furnished by Dr. Klein as regards post-mortem, microscopical, and cultural appearances, as well as the results of inoculation experiments, showed conclusively that the rat had died of plague.

On the same date Dr. Sleigh forwarded a hare which had been found dead in the "Wilderness" (*see H on map*), which is nearly two miles distant from Freston Wood, and this also, as has been said, was pronounced by Dr. Klein to be plague infected.

Subsequently other rodents, mainly rats, were despatched from different parts of the Samford peninsula, and it became gradually manifest that a large number of the parishes in the district contained plague-infected rats.

Professor Simpson also informed me on October 29th that a cat which had died at Stutton Rectory, and which was examined by him, was found to be infected, while a rat and ferret sent to him at my request by Mr. Jervis from Freston were also pronounced by Professor Simpson to have died of the same disease. It was at first thought that the epizootic was confined to the Samford district in which the cases of human plague had occurred, but, as has been already observed, subsequent investigations led to reports of undue rat mortality in the Woodbridge rural district and in the Felixstowe urban district, and, later, both of these areas yielded plague-infected rats as also did the Woodbridge urban district and the outskirts of Ipswich borough.

Shortly afterwards a hare found dead at Mistley (*see map*) in the Tendring rural district of Essex as well as another at Edwardstone (not shown on map) in the Cosford rural district in West Suffolk and some 15 miles west of Ipswich, proved plague infected.

In the first instance the bacteriological investigations were confined almost exclusively to rats which had been found dead under suspicious circumstances, and, while this was the case, the proportion of infected to non-infected rats was considerable. When, however, the undue mortality amongst the rats in the Samford and Woodbridge Unions ceased, and when

the search for rats was extended into districts in West and East Suffolk and into Essex and Cambridgeshire, where there was no definite evidence of undue rat mortality, it became very difficult, even with the most painstaking inquiries, to procure dead rats, and, after a time, recourse was had to the capture and destruction of live rats and the despatch of their carcasses first to London and subsequently to Ipswich for examination. The result, as under the circumstances was to be expected, was that no rats were found to be infected.

Opportunities for the Introduction of Plague into East Suffolk.

As is clearly apparent from the maps the Samford peninsula is bounded upon the north, east, and south by one or other of two large estuaries, one of which, the Orwell, is an important waterway. At what is practically the head of the estuary there stands the county borough of Ipswich, with its 75,000 inhabitants and its docks, the trade of which is increasing annually.

Ipswich is an extremely important centre for the distribution of maize, barley, and wheat, very large quantities of these cereals being introduced by water every year.* As regards malting, Ipswich holds a very high position. This trade in grain is carried on extensively with certain Russian (largely Black Sea) and North and South American ports.

It has already been explained that the larger ships are lightened in Buttermann's Bay, about six miles below the docks, and although, as a rule, the vessels follow when their draft has been sufficiently reduced, sometimes the whole of the cargo may be discharged into barges in the Bay.

Dealing more in detail with the grain ships arriving during the year March 26th, 1909, to March 25th, 1910, there were amongst vessels, from 1,000 tons register and upwards, arrivals from the following amongst other places:—San Francisco (barley), San Nicholas (maize), Valparaiso (barley), Rosario (maize), Alexandria (cotton seed), and it may be noted in passing that in each one of these ports cases of plague have been recorded in one or another of the years 1907 to 1911.

Certain of the vessels referred to entered the Ipswich Docks without lightening, other lightened in Buttermann's Bay and then proceeded to the docks, while a few discharged the whole of their cargo in Buttermann's Bay.†

Amongst those which discharged in Buttermann's Bay were four cotton seed cargoes from Alexandria. Both vessels and barges proceeding to Ipswich discharge their cargoes alongside the docks and a large number of barges may be seen daily loading with grain or its products and afterwards proceeding down the Orwell estuary to various destinations.

* I am indebted to Mr. Edgar H. Drummond for the following figures. During the year ending March 25, 1910, there were imported 289,888 quarters of barley, 303,375 of maize and 170,323 of wheat.

† In the year 1910 25 per cent. of the total shipping entering the port had to be lightened at Buttermann's Bay to 23 feet to enable the vessels to enter the dock. ("Times," March 13, 1911.)

In addition to the direct Ipswich trade in grain, considerable quantities are discharged at Felixstowe Dock from the Black Sea, the River Plate, and Rosario, and it is of importance to note that a certain number of grain ships anchor annually off Shotley Point at the junction of the Orwell and Stour estuaries and there discharge their cargo, or such part of it as are destined for places in the vicinity. Some of it may go to London, some up the Orwell to Ipswich, up the Stour to Mistley, up the Deben to Woodbridge, and up the Alt to Orford, and some may go even further afield.

It seems unnecessary to discuss this matter in further detail, as it is obvious from the foregoing facts that, as some of these vessels come from ports which are now known to be plague-infected (*i.e.*, certain Black Sea ports), and some come from ports which have been plague-infected within the last five years, there are, and have been, opportunities from time to time for the introduction of plague-infected rats into Ipswich, Felixstowe Dock, Mistley, Woodbridge, and other places at which grain-laden vessels or barges are accustomed to discharge their cargoes.

Attention may be called to the fact that there are granaries and mills not only at Ipswich, but also at Felixstowe, Woodbridge, Mistley, and many other places, the grain being frequently conveyed to the smaller ports by means of barges which have taken in their cargo either from some vessel or from the granaries at Ipswich. Reference must also be made to the fact that grain is not infrequently introduced into East Anglian ports from the London Docks, and it has to be realised that grain may be carried to the smaller ports by barges not only from Ipswich, Shotley, and Butterman's Bay, but also from the London Docks.

In other words, this barge traffic may possibly at times afford opportunities for the introduction of rats to the smaller ports. I am informed that rats are but rarely seen on these barges, and it would be easy to exaggerate risk in this sense. But, on the other hand, there can be no question that these barges do offer facilities for rat transference, and on making some inquiries at one of the smaller ports recently, I was informed that occasionally rats are seen on the barges, and that in one instance, what was apparently a black rat (*Mus rattus*), was caught on a grain barge alongside a wharf—the possible significance of which fact is obvious.*

London Manure in Relation to the Rat Epizootic.

At an early date in this investigation relative to rat plague, suggestions were made that the disease had been introduced into the Samford peninsula, and, possibly elsewhere, though the agency of manure from foreign cattle ships which discharge their cattle in the Thames, and, it was alleged, send their manure in barges to the Orwell.

* As an illustration of the conveyance of *Mus rattus* by vessels, it is recorded, in the annual report of the Port Medical Officer of Health of Liverpool, that during the year 1909 of 2,509 rats caught on board vessels or procured from the docks were examined, the majority belonged to *Mus rattus*. Of 329 rats specially examined for the purpose of identification 229 belonged to *Mus rattus*, 98 to *Mus alexandrinus* and 2 to *Mus norvegicus*.

Rat plague was regarded as having been introduced either through the medium of the manure itself or by the agency of rats transported from the cattle ships to the manure barges.

It, therefore, became necessary to make some inquiries in this connection.

It is in the first place desirable, for the information of the lay reader, to point out that plague is a specific disease caused by a definite micro-organism or germ, and that without this organism the existence of plague is impossible. Otherwise stated, no collection of refuse or filth, however putrid, however offensive, can produce plague unless the specific bacillus of plague be present, and it may be said generally on bacteriological grounds that the greater the decomposition of the material and the more its offensiveness, the less likely is it to act as a carrier of the plague bacillus.

It is, therefore, essential, in order to bestow upon the London manure theory of rat-plague causation some degree of probability, to consider how far cattle-boat manure from infected or suspected localities has had opportunity of reaching London and afterwards Suffolk.

If, so far as is known, no cattle manure has within recent years reached this country from plague-infected ports it would not seem necessary to consider the question of manure-borne infection in very great detail.

Careful inquiries have accordingly been made at the Deptford Cattle Market as to the importation of live cattle during the last five years, and it appears that the only countries from which such cattle are now imported into this country are the United States and Canada, no live cattle having reached this country from the Argentine Republic since the year 1903. But, notwithstanding this fact, inquiries have been made relative to the destination of manure from these cattle-ships and of that made at the Deptford Cattle Market by the cattle there awaiting slaughter.

The Canadian vessels which belong to the Canadian Pacific, Allan and Thames Lines come direct to the Deptford Cattle Market, where the cattle are at once landed, and the empty boats proceed immediately to the Surrey and Commercial Docks on the south side of the river to discharge the cattle manure and to be cleansed.

The North American boats proceed direct to the docks at Tilbury, where the cattle are transhipped into smaller boats and brought up to Deptford. Some inquiries were kindly made for me by Dr. Herbert Williams and by the Superintendent of the Deptford Cattle Market as to the destination of the manure taken from both the Canadian and American boats, and they informed me that most of it is put upon barges and discharged at either Erith or Greenhithe; some of it occasionally goes as far up the Medway as Stoke. None of it, I am assured, ever goes further seaward than the mouth of the Medway.

A considerable quantity of manure is produced by the cattle at Deptford while awaiting slaughter, and this is placed in barges and taken down the Thames to places such as Maldon and Bradwell in Essex and up the valley of the Medway as far as Maidstone. None, so far as is known, goes into Suffolk.

In addition to the cattle trade, horses are brought from Libau in Russia and landed at Milwall Docks, the manure from these vessels being taken to Rainham in Essex.

With respect to the manure trade in the Samford peninsula, it is carried on very largely, but not exclusively, by a farmer who farms a large quantity of land in this peninsula, and who introduces large quantities of manure from Providence Wharf, Vauxhall, at which wharf, I was informed, that almost the only manure dealt with is derived from stables and, very occasionally, from cowsheds. No other manure or refuse is ever, so I am informed, despatched from this wharf, and the manure dealt with is obtained almost exclusively from Lambeth. Some, however, is occasionally procured from Wandsworth.

Most of this Providence Wharf manure goes, it seems, to the Samford peninsula, but some of it is sent to Blackwater and Great Wakering in Essex by barges, and some occasionally to Faversham and Maidstone in Kent.

There would appear to be no object in furnishing detailed information relative to the destination of all the London manure and street and house refuse, more especially as there have been no cases of human or rat plague actually in London itself for very many years. It may, however, be stated that, through the kindness of Sir Shirley Murphy, I have received very full information as regards the destination of London refuse, and much assistance in the same direction has been afforded me by Dr. Collingridge, Medical Officer of Health of the City of London, and by Dr. Herbert Williams, Medical Officer of Health of the Port of London.

From the information thus obtained it seems that London manure and refuse is despatched either by rail or barge to the following counties—Bedfordshire, Berks, Bucks, Cambridgeshire, Essex, Herts, Kent, Lincolnshire, Middlesex, Northamptonshire, Suffolk, Surrey, and Essex; but of these several counties a relatively small amount reaches Suffolk. Part of this total goes, as has been said, by barge from Providence Wharf, Vauxhall, part by train from Islington, via Tufnell Park station, while the Great Eastern Railway send some by train from Stoke Newington and Hackney. There may also, of course, be other sources which have not come to my knowledge. The information from the above sources is also to the effect that cattle manure from the docks, as well as horse manure from Russian ships, does not go into Suffolk.

Considerations as to point of Introduction of Rat Plague.

The question of the source and point, or points, of introduction of this rat plague into East Anglia is one concerning which, from the very nature of the problem, no actual proof can be obtained.

If the alternative methods be looked at from the view point of probabilities much might be adduced in support of a view that the original centre of diffusion was Ipswich, and this mainly by reason of the very large grain trade carried on at the Ipswich Docks, and by the opportunities which exist in such docks for the access of rats from the ships to the shore as compared, for instance, with the obstacles to such introduction which are presented at

Butterman's Bay. But against this view is the important consideration that no mortality of rats has been observed at least during the last five years in the Ipswich Docks, and this notwithstanding the fact that plague-infected rats have been found in the outskirts of the town.

It must, however, be borne in mind that the history of plague during the last quarter of a century has shown how frequently the disease has been introduced via the docks in places where it has obtained a footing, and similarly such history also indicates how easily dead rats may be overlooked unless floors are taken up and a careful search made. In numerous instances, save for the presence of smell or active search, rat mortality would have passed unobserved.

In like manner the history of plague, from the thirteenth century onwards, shows how frequently the disease has been introduced through the agency of foreign shipping, and it shows, moreover, that in almost every instance the first cases of human plague have been overlooked, or only recognised, as was presumably the case at Freston, after death.

In what manner did the Epizootic spread in Suffolk.

The question arises as to the mechanical means by which the rat epizootic spread over such a wide area, and as to the period which was occupied in its diffusion. Did the disease spread in whatever direction it may have been diffused, whether from one or more centres, by the migration of affected rats from one area to another, or did it spread slowly from rat to rat by direct flea transmission, or through the visits of healthy rats to rat nests infested by plague-infected fleas?

As regards the question of the actual occurrence of rat migration there is considerable difference of opinion. That the brown rat (*Mus decumanus*) does migrate over enormous distances and over estuaries, rivers, and canals is well established in history; and, further, it is matter of common knowledge that rats in this country are found in hedgerows in summer and in the stacks and barns in winter; in other words, the rats, like other animals, endeavour to live, so far as practicable, in the vicinity of their food supplies, as Drs. Martin and Rowland show in their observations upon the habits of the brown rat. But restricted movements of this character are not quite the same thing as is understood by the term migration, that is to the occasional movement of rats over long distances in search of food or to avoid their pursuers. We have the high authority, in so far as India and the black rat (*Mus rattus*) is concerned, of the Indian Plague Commission to the effect that no migration of rats has been observed in that country, and, as regards Great Britain, it is difficult to obtain anything which can be regarded as reliable evidence of rat migration.

It is important, however, to observe that the habits of *Mus rattus* and *Mus decumanus* are very dissimilar, and that inferences as to the habits of the latter cannot safely be drawn from observations on the former.

It is sometimes inferred because rats are seen to be dying first in one place and then in another, that the sick rats are

migrating, but, obviously, the spread of the disease from the rats of one district to the rats of another district would be an equally good explanation of this phenomenon.

It seems, however, clear that rat migration *en masse* is in no sense an essential condition for the spread of a rat epizootic.

Transmission of infected fleas, either through the agency of isolated rats or even without such agency, would in large part explain the diffusion of rat plague as observed in East Anglia, where investigations, which were made by Drs. Martin and Rowland, suggest, so far as they went, that the plague-infected rats in parts of East Suffolk occur in "pockets" or circumscribed areas, and that between such areas there may be a plague-free rodent population.

Some instructive observations in connection with this question of the transmission of rat plague from place to place, are contained in Vol. 8, No. 4, of the "Journal of Hygiene."*

In discussing the dispersion of rat fleas with their hosts through the agency of merchandise, attention is drawn to the ease with which fleas can be transported with grain.

It is stated that rats have been seen to dive into bags containing grain and bran, and to disappear in such a fashion that the bags could be moved without any evidence of the presence of the contained rodent.

It is pointed out that the habits of *Mus rattus* render these animals particularly liable to be transported in this fashion.

That fleas can be transported without their hosts in merchandise of different sorts, especially in grain and clothing, has been experimentally demonstrated by the Commission, who on one occasion found numerous rat fleas in bran which had been kept in a bin, with loosely fitting lid, in a rat-infested room. It is observed, however, in this connection that adult fleas, in the absence of any hosts, generally die in about five days. Other experiments went to show that fleas may often be transported in clothes from place to place, especially from plague-infected houses, where they are more likely to take to man owing to the absence of their true hosts.

The Commissioners also point out that as regards the importation of infection into a hitherto infected locality, that whether rat fleas be transported in clothing or merchandise they will select in preference their true host the rat, but, if this be absent, they will attack the human occupant of the house.

It is clear, therefore, that the introduction of infected fleas in the above sense may give rise either to an outbreak of rat or human plague according to circumstances. But as regards East Suffolk, as will be seen by the course of the several rivers, the opportunities afforded by the barges for the transportation of rats cannot be overlooked, and these opportunities are such as to offer an explanation in part of the ascertained rat prevalence.

* Fourth Extra Number, containing reports on Plague Investigations in India.

It is obvious to anyone visiting the Ipswich docks and smaller ports, such as Felixstowe, Woodbridge, and Mistley, that rats can without any very great difficulty obtain access from ship or barge to shore or *vice versa*.

Doubtless were any of the places from which the vessels or barges come known to be rat-plague infected, such precautions as are available for preventing access of rats to or from the vessels or barges would be taken, but prolonged experience raises serious question whether such precautions are wholly effectual. The presence of infected hares in localities possibly far removed from the rat-infected areas is not difficult to explain, since it is not improbable that these animals may traverse considerable distances even in a single day, and it may be added, with respect to the plague-infected hare at Edwardstone, in the Cosford rural district, that grain-laden barges occasionally go up the River Stour as far as Bures, which is only some five miles from Edwardstone.

It has, too, to be borne in mind that grain-laden barges pass up the several estuaries to considerable distances inland, and it is only necessary to study the accompanying maps carefully to understand the manner in which it is possible that plague infection might be introduced at several separate points.

Dr. Sleigh, the medical officer of health of the Samford rural district, draws attention in his paper, to which reference has been made, to the circumstance that the Shotley group of cases (dealt with in detail later) occurred at a spot immediately opposite the anchorage of the large grain-laden boats in Butterman's Bay, and he expresses the opinion that it would be an easy matter for rats from these vessels to swim ashore at this point.*

The records of rat migration certainly lend support to the possibility of such a short swim.

It is clearly not possible with the evidence available to determine at what point the epizootic was introduced, or to form any conclusion as to the direction in which the disease amongst the rodents travelled. The groups of human illness are too few and, as it were, too accidental to furnish safe ground for inferences.

If, as some believe, the rat disease was introduced into Shotley *viâ* Butterman's Bay, and if, moreover, this was the only introduction, then unless infected rats swam the Orwell either from a

* Lydekker in "Royal Natural History," observes that—Rats impelled by scarcity of food at times make emigrations in large bodies, generally during the night; and on such occasions they will not hesitate to plunge boldly into or swim over such rivers as may come in their way. Some years ago the rats that frequented the London Zoological Gardens were in the habit of regularly swimming to and fro across the Regent's Canal.

It is also narrated by Zuschlag that two fishermen who had witnessed the occurrence, stated that during a night in the autumn of 1847, while they were fishing in the Limfjord, a broad channel in Jutland, their boats were surrounded by immense swarms of rats making for the Peninsula of Sky. Shortly afterwards the whole peninsula was overrun by the brown rat, the black rat having been exterminated.

Boelter states that in the Faroe Islands the brown rat is ubiquitous, and that the rats may frequently be seen swimming *en masse* across the strait dividing the islands of the Archipelago.

grain-ship in the river or from the Samford shore, the epizootic must have travelled via Ipswich through the Woodbridge rural district to Woodbridge town and to Felixstowe. It must, moreover, have crossed the estuary of the Deben at some point in its course since an extensive "pocket" of plague-infected rats was found by Drs. Martin and Rowland at Hollesley Bay (*see map*).

An observer examining the map of the locality with a knowledge of the important grain trade carried on in Ipswich, and having regard to the distribution of the epizootic, would probably arrive at the conclusion that notwithstanding the absence of evidence as to rat mortality in the Ipswich Docks, Ipswich was the centre of diffusion of the epizootic, but possibly some years ago. But however probable this may appear, there is certainly, as Dr. Pringle has pointed out,* no conclusive evidence that this was actually the case. Nevertheless, the discovery of plague-infected rats in the outskirts of Ipswich is, to say the least of it, a very suspicious circumstance. But it is also by no means improbable that there were multiple introductions of rat plague, and that at a certain period plague rats were introduced by grain ships or barges at Chelmondiston, Ipswich, Felixstowe, Mistley, Woodbridge, and other places, and that from one or more of these centres the epizootic diffused itself.

The Immunity of the Human Population in relation to the diffusion of the Epizootic, and the Lessons to be drawn therefrom.

Evidence has already been adduced pointing to the conclusion that there was undue mortality amongst rodents in the Samford peninsula in 1907, as well as in 1910, and there is also evidence that in both these years, as well as in the Woodbridge union in 1909-10, there may have been isolated outbreaks of human plague—one primary case in each instance followed by a few secondary cases.

Unless three separate introductions of rat plague are to be assumed, it would seem not improbable that the epizootic has been in existence since 1907 or even earlier, at least, in so far as the Samford union is concerned, and, if this be a fair inference from the facts, rat plague may have persisted by means of a few acute cases throughout three summers, with but a minimum amount of human plague; in fact, during the actual summer months, unless as seems improbable cases were overlooked, with none. Furthermore, there is the significant fact that from mid-October, 1910, up to about the end of January, 1911, very many thousands of rats were destroyed in the invaded districts of Samford and Woodbridge rural districts, and in the

* The outbreak of Rat Plague in Suffolk by A. M. N. Pringle, M.D., D.P.H., Medical Officer of Health of Ipswich. Public Health, No. 4, Vol. XXIV, January, 1911.

Woodbridge and Felixstowe urban districts, without the occurrence of one case of human plague. It must, too, be remembered that this rat destruction was for the most part carried out by persons who were unaware of or, at least, who did not fully appreciate the danger which they might be incurring from rat fleas, and that, consequently, notwithstanding advice which was given them, few precautions were taken to prevent the transmission from rat to man of possible plague-infected fleas.

The explanation of this human immunity may in part be due to the fact that the rat destruction process took place in the open country during the winter months when the rat flea population in this country is probably at its lowest. But there may probably be a more dominant factor at work in the circumstance, that the rat which is in question in this country is, for practical purposes, exclusively *Mus Norvegicus vel decumanus*, the habits of which are essentially different from those of the black rat of India (*Mus rattus*), which is largely a domesticated animal, and which, from the circumstances of Eastern life, is brought far more intimately into relation with the human population than is the case with *Mus decumanus*, which inhabits mainly the hedgerows and stacks and which largely avoids the vicinity of man. Moreover, the rat flea of *Mus rattus* is *Xenopsylla cheopis* formerly known as *Pulex cheopis*, which bites man readily and which infests the rats freely.

The investigations of Drs. Martin and Rowland, an account of which follows, tend to show that at any rate in East Suffolk the rat-flea population in the winter months of 1910-11 was a very scanty one, averaging under one flea per rat, and that the *Xenopsylla cheopis* was absent. Moreover, more than 50 per cent. of this rat-flea population was made up of *Ctenophthalmus agyrtes*,* a flea which, so far as the limited experiments carried out up to the present indicate, rarely, if ever, bites man; the remainder of the rat-flea population being composed of *Ceratophyllus fasciatus*, which bites man, but not nearly so readily as does *Xenopsylla cheopis*. There is thus left on the average less than half a man-biting flea per rat.

As further bearing upon the immunity of the human population in East Suffolk, attention may be directed to some experiments carried out by the Indian Plague Commission as to the transmission of plague by fleas.† In the course of this investigation, some experiments were conducted with the view of ascertaining whether a single flea taken from a septicæmic-plague rat could transmit the infection to the white English rat, which, as is well known, is extremely susceptible to plague.

Out of 67 experiments made, only in one instance was plague transmitted through the agency of a single flea, although it was estimated, on the basis of some previous experiments,

* Of the 584 rat fleas 324 were *Ceratophyllus fasciatus* and 259 *Ctenophthalmus agyrtes*.

† "The Journal of Hygiene," Vol. 7, No. 3, July, 1907.

that some 50 per cent. of the fleas employed in the investigation would contain plague bacilli in their stomachs.

Moreover, Drs. Martin and Rowland observe in their report upon their investigations in Suffolk, that an infestation of this degree was not found sufficient to give rise to a human epidemic in India, notwithstanding the vastly greater accessibility of mankind for rat fleas.

Lessons as to the possible behaviour of plague in this country in the future are occasionally drawn from the experience of England in the fourteenth century during the prevalence of the Black Death, and during the seventeenth century during what was erroneously termed the Plague of London. But inferences from these events need to be drawn with much circumspection, since the circumstances, both zoological and social, are at the present time very different from those which obtained in the fourteenth and seventeenth centuries.

If reliance can be placed upon the history of rat migration, it would seem that at the time of both the visitations of plague here referred to, the black rat (*Mus rattus*) was the dominant rodent, and although there was probably not at this time the same intimate association between the inhabitants and the black rats as obtains amongst the Indians at the present day, the natural habit of *Mus rattus* would assert itself, and the crowded, ill-ventilated, badly lighted, and badly drained houses of this time would all tend to facilitate the accessibility of the rats to human habitations.

It is said that the Black Rat (*M. rattus*) was not indigenous to this country, but that it was introduced from Persia into Northern Europe about the twelfth century. According to some writers it came to England with William the Conqueror. Others take the view that the Black Rat is a variety of *Mus Alexandrinus* and that it was associated with the plagues recorded by Thucydides and Justinian.

The Brown Rat (*Mus decumanus*) did not apparently reach this country until about the year 1728, *i.e.*, until several years after the disappearance of human plague from the British Isles.*

As regards the social habits of these periods, it is scarcely necessary to point out that the practice which then obtained of shutting up together in the invaded houses the sick and the healthy together, was eminently calculated to facilitate intercourse between rats and man and between man and man, and thus to spread the malady.

The history of the plague in the fourteenth and seventeenth centuries was very different from that of the plague in India at the present day, where it is, it seems, but rare to discover multiple cases of the disease in the same house. Whereas in the fourteenth and seventeenth centuries the disease seems not infrequently to have attacked the whole personnel of an invaded dwelling.

The question, of course, arises as to the proportion of pneumonic or septicæmic cases of plague to those of the purely

* The Rat Problem by W. R. Boelter.

bubonic type in the fourteenth and seventeenth centuries, but a discussion as to this can hardly be embarked upon in the present report.

It may, however, be added that pneumonic plague appears to have played a far more important part in the spread of plague at certain phases of several past epidemics than is commonly believed.

The Seasonal Behaviour of Plague in Great Britain.

In view of the uncertainty which obviously obtains as regards the future with respect both to rodent and human plague, it will be useful to indicate by such figures as are available the months of the year during which in the past human plague has mainly prevailed in this country.

It may be pointed out that most of the acute infectious diseases manifest a marked seasonal behaviour, some of such diseases, of which small-pox may be taken as an example, prevailing mainly in the winter months, while others, like enteric fever and scarlet fever, prevail more particularly in the late summer and autumn months. In the case of plague its seasonal behaviour differs in eastern and western countries. In China and India* the malady reaches its height during the winter months, and in Egypt the disease appears in autumn and dies out in June. In this country and in the western parts of Europe the chief manifestations of the disease have been in the summer and autumn months.

In other words plague in Western Europe tends to die down in cold wintry weather. In the East it is otherwise especially with pneumonic plague where, as in Manchuria, plague may prevail in the presence of intense cold.

Going back as regards London to the first Bill of Mortality extant, that for the year 1563, the average weekly mortalities recorded from plague alone were as follows:—

Year.	Month.	Average Weekly Mortality.	Year.	Month.	Average Weekly Mortality.
1563	June	22	1564... ..	January	24
"	July	112	"	February	19
"	August	596	"	March	6
"	September	1,351	"	April	4
"	October	1,165	"	May	3
"	November	363	"	June	2
"	December	184			

In 1578 the deaths were most numerous at the end of September, in 1579 at the end of August, in 1580 in the middle of June, in 1581 in the middle of September, and in 1582 in the middle of October.†

* See charts showing seasonal prevalence of Plague in Bombay and Calcutta. Reports and Papers on Bubonic Plague by Dr. R. Bruce Low, with introduction by the Medical Officer of the Local Government Board, 1902 [Cd. 748], price 4/1.

† The Climatic Conditions necessary for the Propagation and spread of Plague—by Baldwin Latham.

History of Epidemics—Creighton.

Coming now to the seventeenth century the following tables are of interest:—

*Deaths from Plague in London in the Seventeenth Century according to the Bills of Mortality.**

1603 (epidemic) ...	33,347	1648	611
1609 (minor epidemic)	4,240	1650-1662 (average)...	15
1625 (epidemic) ...	41,313	1663	12
1636 (minor epidemic)	10,400	1664	5
1637-1646 (average)...	1,500	1665 (epidemic) ...	68,596
1647	3,597	1667	1,998

Monthly Mortality in 1665.

January	0	July	6,137
February	1	August	17,036
March	0	September	26,230
April	2	October	14,373
May	43	November	3,449
June	590	December	734

In Colchester in 1665 the maximum number of deaths occurred near the end of September, but it prevailed in this town until the end of 1666, there being a very heavy mortality therefrom in the months of May, June, and July of that year.

Gideon Harvey† in his discourse on the plague, shows clearly that the seasonal prevalence of the disease was recognised, since he observes: "at present it is in the augment and likely to attain to a state about the latter end of August or September according to observations of preceding plagues that have begun at the same time and season."

* See Dr. Payne's introduction to "Loimographia." Transaction of the Epidemiological Society of London, New Series, Vol. xiii., Session 1893-94. The statistics themselves are taken from London's Dreadful Visitation and Graunt's Observations on the Bills of Mortality.

Mead's Medical Works, Vol. I, p. 290.

The History and Antiquities of Eyam with an account of the Great Plague, by William Wood.

Creighton's History of Epidemics, Vol. I.

It should be noted that deaths from plague were recorded in the Bills in every year from 1603 to 1679 when the last deaths from this disease occurred. In the year 1704 all reference to the disease was omitted from the Bills.

The following figures relative to London, taken from Creighton's History of Epidemics in Britain, are instructive:—

Year.	Estimated Population.	Total Deaths.	Plague Deaths.	Highest Mortalities a week.	Worst Weeks.
1603	250,000	42,940	33,347	3,385	Aug. 25—Sept. 1.
1625	320,000	63,001	41,313	5,205	Aug. 11—18.
1665	460,000	97,306	68,596	8,297	Sept. 12—19.

† A Discourse of the Plague containing the Nature, Causes, Signs and Presages of the Pestilence in general. Published for the benefit of this great city of London and Suburbs by Gideon Harvey, M.D. Printed by Nath. Brooks at the Angel in Cornhill, 1665.

An instructive illustration of seasonal influences and of apparent re-awakening of infection is afforded by the historical outbreak of plague which occurred at Eyam, a village in the High Peak of Derbyshire, into which infection of plague is alleged to have been introduced from London with a box of old clothes at the beginning of September, 1665. The disease, which was apparently bubonic plague, manifested a remarkable infectivity and fatality. The total population of the village at the commencement of the outbreak was stated to have been about 350, but as the burials in 1661 were 24, in 1662 23, and in 1664 22, it is probable that the population was more than double that referred to. The following table shows the monthly burials during the epidemic:—

1665 :				1666 :			
September	...	...	6	April	...	...	9
October	...	...	23	May	...	...	4
November	...	...	7	June	...	...	19
December	...	...	9	July	...	...	56
				August	...	...	77
1666 :				September	...	...	24
January	...	...	5	October	...	...	14
February	...	...	8				
March	...	...	6				267

Probably 8 of the above died from diseases other than plague, as the Rev. William Thompson, the vicar whose heroism kept him at his post, attributed only 259 cases to plague. These 259 persons were comprised in 76 families, and it would thus appear that some 3·4 cases occurred on an average in each invaded house. It is not clear that pneumonic plague formed at all a significant feature of the outbreak, but the severity of the attacks and the occurrence of several cases in the same house suggests that septicæmia plague may have prevailed.

The history of plague in Great Britain after the close of the seventeenth century affords us no information as to seasonal manifestations, since during the nineteenth and twentieth centuries the localised outbreaks have been too small to attach much value to from a statistical standpoint. It may, however, be observed that amongst European outbreaks that of Moscow* in 1771-1777 reached its climax in September, the monthly figures, as regards deaths, being as follows:—

April	...	...	778	August	...	...	7,268
May	...	...	878	September	...	...	21,401
June	...	...	1,099	October	...	...	17,561
July	...	...	1,708	November	...	...	5,235
				December	...	...	805

* Handbook of Geographical and Historical Pathology by Dr. August Hirsch.

An account of the Plague which raged at Moscow in 1771, by Charles de Mertens, M.D., 1784. Written originally in Latin, translated into French, and finally into English, 1799.

A Treatise on Plague by W. J. Simpson.

A similar summer and autumn maximum, moreover, was observed in the plague of Marseilles in 1720,* and that of Dantzic in 1709, while with respect to Oporto (in 1899) the greatest number of cases occurred in October, as is shown below:—

June	17	September	41
July	10	October	99
August	36	November	80
		December	27

The limited outbreak which occurred at Glasgow in 1900 (36 cases with 16 deaths) took place in August, as also did that of the following year (10 cases with 5 deaths). In 1907 a girl was attacked with plague in the same street in which the disease was first discovered in 1900, and in October of the same year a boy residing in the same locality was taken ill with the same disease.

The Freston outbreak occurred in September, 1910, and the Trimley and Shotley outbreaks to be referred to later, both of which may have been plague, in the winter months.

It may also be mentioned, as possibly having some bearing upon this question of season, that in August and September, 1908, rats dead of plague were found in the London Docks. But on the other hand rats similarly affected were found in the Docks at Hull in January, 1909, and on board a vessel from Alexandria to Bristol in November, 1909. But these latter events must be regarded as casual incidents possessing no statistical value.

Certainly the evidence as regards plague in this country and in Western Europe points definitely to the conclusion that the disease is most likely to prevail, if at all, in the summer and autumn months, a fact which should call for special vigilance at that period of the year in East Anglia.

PART II.

Administrative Measures.

On my arrival at Ipswich on October 3rd the medical officer of health of the invaded district informed me that all the contacts had been isolated and placed under observation, that measures of disinfection had been taken, and that both the invaded houses had been evacuated.

I at once placed myself in communication with Dr. Carey, who had attended the patients first attacked, and examined the death returns of the district to ascertain whether there had been other deaths the nature of which would cause suspicion of plague. I

* A Journal of the Great Plague of Marseilles in 1720.

Dreadful Plague at Marseilles, considered and compared with that terrible one of London in the year 1665. Printed by H. Parker, Goswell Road, 1721.

Plague in Oporto by A. Shadwell, M.D. Transactions of Epidemiological Society of London, Vol. xix., Session 1899-1901.

Bubonic Plague by J. V. Montenegro, M.D., 1900.

Reports and Papers on Bubonic Plague by Dr. R. Bruce Low, with an introduction by the Medical Officer of the Local Government Board, 1902.

conferred too with Dr. Herbert Brown and Dr. Llewellyn Heath, of Ipswich, as to the clinical and bacteriological manifestations respectively observed by them.

I also commenced investigations as to the possible sources of the Freston outbreak, and, incidentally, into the outbreaks of illness which occurred at Shotley in the winter of 1906-7 and at Trimley in the winter of 1909-10, and a detailed account of these two groups of illness follows. Inquiries were made into the question of any undue mortality amongst rodents in the district, and samples of rats and other rodents found dead were obtained for examination by Dr. Klein. As a result of these investigations it soon became clear that there had been undue mortality amongst rats in the invaded locality, and that such mortality was due at least in some degree to plague.

Conferences were, therefore, held with the chairman and officers of the Samford Rural District Council and subsequently with a Joint Committee of this Council and the Ipswich Town Council with the object of arranging for systematic action as regards rat destruction and precautions in the invaded and threatened districts. Posters enjoining rat destruction, caution in handling rats, the removal of refuse from the vicinity of houses, and other necessary measures were drawn up and freely circulated in the Samford Rural District, and the services of the police were enlisted in the diffusion of the necessary information.*

In the first instance it was found difficult to obtain the services of a competent and reliable rat-catcher to direct and supervise the operations in the Samford district, but, subsequently, some 20 or 30 rat-catchers were employed and the work of rat-destruction, carried out in systematic fashion over the whole of the Samford district, both to the east and to the west of the Great Eastern Railway line.

The medical practitioners were asked to notify to the medical officer of health any suspicious cases of illness amongst their patients, arrangements were made for the isolation of any further actual or suspected cases of pneumonic plague which might occur, and a supply of Haffkine's plague prophylactic was obtained by the medical officer of health for use should occasion demand it. Fortunately, although a careful vigil has been kept, no suspicious cases of illness have arisen in the district since the occurrence of the Freston cases.

In addition to conferring with the representatives and officers of the Samford Rural District and carrying out prolonged investigations in the locality, I conferred subsequently with the officers of nearly all the administrative districts in East Suffolk, who were also formally communicated with by the Local Government Board.

At each place visited inquiries were made as to any undue mortality amongst rodents, and arrangements were made for the

* I also conferred with the Secretary of the Great Eastern Railway, who at once gave orders that the rat-catchers in the employ of the Company should all concentrate their efforts upon that portion of the main line which extends between Ipswich and Manningtree.

despatch to London of any dead rodents for bacteriological examination.

Rat destruction was advocated as a precautionary measure even where no dead rats were discovered, the notification of any suspicious cases of illness was arranged for, the provision of isolation accommodation and nursing arrangements to be ready beforehand was strongly urged, and advice was given as to procuring a supply of Haffkine's plague prophylactic.

The issue of placards was enjoined dealing with the danger of handling dead rats, the importance of rat destruction, the necessity for the removal from the neighbourhood of houses of all garbage and refuse likely to harbour rats, and the desirability of rendering houses rat-proof and of remedying defective drainage.

Special attention was directed to overcrowded, insanitary, and dirty premises, and to places such as slaughter-houses, bakeries, restaurants, granaries, and other places likely to harbour rats.

With respect to rat destruction, action, varying in degree and thoroughness in different districts, was very generally taken, the owners and occupiers of property carrying out their responsibilities in this connection in a praiseworthy fashion. There were, however, some exceptions to this rule.

The degree of rat destruction varied according to the enthusiasm and organisation with which it was taken up by the district councils, and some good results were secured in instances where methodical efforts were made to interest the several parochial representatives in the movement.

A variety of methods were adopted. In some instances the district councils supplied poison or virus free of charge; in others they employed rat-catchers, and in others again a pecuniary reward per rat-tail was offered. In some instances the district council contented itself with the issue of placards.

As the investigation advanced it became necessary to visit districts outside East Suffolk—*i.e.*, in West Suffolk and in Essex—and it was soon obvious that the area involved was beyond the powers of one inspector. Consequently, my colleagues, Drs. Fletcher and Reece, were given charge of Essex and West Suffolk respectively.

Rat Destruction Order.

Early in November it became apparent that although for the most part the owners or occupiers of property fulfilled their obligation by assisting the district councils as regards rat destruction, there was a certain number who persistently abstained from action.

With a view, therefore, of enabling district councils to undertake and promote rat destruction, the Local Government Board issued, on November 10th, 1910, an order under the powers conferred upon them by the Public Health Statutes.

This order, a copy of which will be found in the Appendix, authorised and required local authorities to take measures for the destruction of rats and for preventing the entrance of these animals into buildings and other premises.

Memorandum on Plague.

The Board's memorandum on plague was freely circulated in the invaded districts, and as this memorandum was in certain particulars out of date, it was recast by the medical officer as rapidly as possible and sent to the officers in all the invaded districts, as well as generally throughout the country. (See copy of memorandum annexed.)

Arrangements made for the Bacteriological Examination of Rodents.

In the first instance the bacteriological examination of rats and other animals was confined to those found dead in different parts of East Suffolk, and arrangements were made for the transmission of such animals, with due precautions, to the Local Government Board for examination by Dr. Klein. Subsequently this arrangement was extended to West Suffolk and to parts of Essex and Cambridgeshire, and, as a result of these arrangements, a large number of animals were bacteriologically examined for plague. Not only did rats and other rodents arrive from the areas referred to, but also occasionally from other parts of England.

As, however, considerable delay often occurred in obtaining rats found dead under suspicious circumstances, it was determined that when such rats could not be procured, live rats should be killed for the purpose of examination.*

It seemed desirable, with a view to determine if practicable the limitation of the rat epizootic, to investigate the condition of a larger number of rats than could be examined bacteriologically, and the Board arranged, after consultation with Dr. Martin, F.R.S., Director of the Lister Institute, to obtain and examine 500 rats from each of eleven unions with their contained sanitary areas in East and West Suffolk and in Essex. These districts were selected by the Board as being those most likely to afford valuable information, and they were as follows:—

East Suffolk:	Essex:
Hartismere.	Lexden and Winstree.
Hoxne.	Tendring.
Blything.	Colchester.
Plomesgate.	Belchamp.
East Stow.	Halstead.
West Suffolk:	Braintree.
Melford.	Maldon.
Thingoe.	
Theedcastre.	

For the purpose of arranging for the systematic despatch of rats from the selected areas the several unions were divided between my colleagues, Dr. Fletcher, Dr. Reece, and myself; and through

* Drs. Martin and Rowland, in the course of an investigation undertaken by them into the flea fauna of local rats, examined a number of rodents in the Woodbridge Union during the winter of 1910-1911, and an account of their work is embodied in the next section of this report.

the cordial co-operation of the officers and, in some instances, of the district councillors, of the several areas (whose assistance is here gratefully acknowledged), the necessary number of rats were despatched in boxes specially designed by Dr. Reece. The examination took place at the Municipal Laboratory at Ipswich, which had been courteously placed at the disposal of the Board by the Town Council of Ipswich, and which had been prepared for the purpose, under the direction of Dr. Pringle, the medical officer of health.

The examination of the rats was entrusted by the Board to the Lister Institute, and was undertaken by Dr. Petrie and Dr. MacAlister, together with a trained staff of laboratory assistants, who had been brought down from that Institute for the purpose.

Section III. of this report deals with these investigations.

Work of the East Suffolk County Council.

Reference has already been made to the bacteriological investigations carried out by Dr. Heath, bacteriologist to the Ipswich and East Suffolk Hospital, and on November 1st the East Suffolk County Council, recognising the advantages which would accrue from the services of an advisory officer, appointed Dr. Heath to advise the public health committee, to consult with the district medical officers of health, and to carry out bacteriological examinations. A special report upon the work done was issued by the County Council, and extracts from the report will be found in the Appendix.

Precautions as regards the future.

The absence of further cases of human plague does not justify the belief that all danger has passed and that precautions can be relaxed. The history of plague both in this and other countries should suffice to show the danger of such a policy. It is probable that the first indication of danger will, as in the case of the Freston outbreak, where it was unfortunately ignored, or rather not understood, take the form of mortality amongst rats or possibly other rodents. Consequently in every district and in every parish and hamlet the greatest vigilance should be exercised in this particular, and arrangements should be made by every sanitary authority for receiving the earliest intimation of death amongst rodents and the receipt of specimens of such animals for bacteriological examination by the Local Government Board. This should be a very simple precaution to take, and it is the one which should be put to the forefront of all preventive measures. Practically all the outbreaks of bubonic plague at the present day are found to be preceded, if diligent search be made, by mortality amongst rats or other rodents, and where such mortality obtains the risk of the human population being involved is considerable.

It is conceivable that a large number of rats in the invaded localities may now be relatively immune from plague, but as a

young rat population arises there will grow up a large unprotected rat population prone to die off if and when the rat epizootic appears. Consequently *persistence* in rat destruction is called for.

But the total destruction of the rat population is a difficult problem, and the additional precaution required is to render the houses as far as practicable rat-proof, and to remove from the vicinity of houses all garbage and refuse likely to harbour rats or attract them to the neighbourhood of dwellings.

With respect to the human population equal vigilance is necessary by way of seeking immediate medical advice when any symptoms suspicious of plague occur; such, for example, as any painful swellings in the armpits, groin, neck, or other parts of the body, or the occurrence of any lung condition which might excite suspicion of pneumonia.

Efforts should be made on the part of all sanitary authorities not already provided with isolation accommodation to provide it either alone or in conjunction with neighbouring authorities. In this connection it should be remembered that to be of use an isolation hospital should be ready beforehand so that patients can be removed at the earliest practicable moment. It will often be found that the best isolation accommodation can be secured by the combination of two or more sanitary authorities either under the provisions of the Public Health Act, 1875, or the Isolation Hospitals Acts.

A supply of Haffkine's plague prophylactic should always be held in readiness by the medical officers of health, as also should capillary tubes and bottles for the despatch of blood, sputum, or other material from human cases for bacteriological examination.

And with regard to general sanitary measures the greatest attention should be paid to the poorest, most insanitary, overcrowded, and dirtiest property, since it is on premises of this description that plague is most likely to occur, and the pneumonic variety of the disease is most easily spread.

PART III.

The Trimley and Shotley Outbreaks.

An account is herewith furnished of two extremely interesting outbreaks which occurred on the banks of the Orwell in the winters of 1909-10 and 1906-7, respectively, and to which the Freston outbreak had at once drawn public attention. Unfortunately, the data available were not as full as could have been wished, but, having regard to the importance of the outbreaks from an epidemiological point of view, a considerable amount of time was spent in collecting the evidence herewith set forth. It seems difficult to account for the occurrences in any better fashion than on the theory that they were plague, and this notwithstanding the many lacunæ in the narratives.

The Trimley Outbreak.

In December, 1909, and January, 1910, there occurred at Lower Street, Trimley (marked C on map) a series of seven cases of illness under circumstances which occasioned much local interest and speculation, which were not adequately explained, and which resulted in the loss of four, if not five, lives. The family first involved lived in one of a pair of cottages situated in a position a little westward of the Ipswich and Felixstowe Railway, and rather under a mile distant from the Orwell.

The invaded cottage consisted of two rooms only, a dwelling-room on the ground floor and a bedroom above, under a slanting roof; and the family at home comprised the father and mother, two daughters and three sons.

The father was occupied as a horseman on a neighbouring farm, and the family were in very poor circumstances. There was, obviously, overcrowding, and the house was said to be infested with fleas (presumably *Pulex irritans*).

It will facilitate the account of the outbreak if a table of the persons attacked be at once furnished.

Initials.	Age.	Sex.	Date of Attack.	Date of Death.	Date of Burial.	Remarks.
H. R. ...	46	F.	Dec. 19, 1909.	Dec. 23	Dec. 25	Found dead in bed.—Inquest.
C. R....	14	F.	Dec. 26, 1909.	Jan. 5	Jan. 8	
A. R. ...	9	F.	Jan. 8	Jan. 10	Jan. 13	Post-mortem and inquest.
W. G. R. ...	50	M.	Jan. 9	Recovered.		Removed to Ipswich Hospital, Jan. 10.
*W. R. ...	12	M.	Jan. 15	Jan. 17	Jan. 21	
*J. R. ...	6	M.	Jan. 18	Recovered.		Removed to Ipswich Hospital same day.
H. R....	18	F.	Jan. 20	Recovered.		Removed to Ipswich Hospital, Jan. 22.
H. F....	7	F.	Feb. 3	Feb. 6	Feb. 11	Operation, post-mortem and inquest.

* Both removed to Barham Workhouse, Jan. 11th.

The first inmate to be attacked was the mother, H. R., aged 46, who, on December 19th, 1909, rose with a headache and suffered from diarrhœa and vomiting. As she became worse she went to bed at 4.30 p.m. Although she was obviously weak and unwell for the next two days, she remained at work as long as possible, and she did not, the daughter alleges, appear to be really seriously ill until some three or four hours before her death. Consequently, no medical advice was sought. She was found dead in bed on the afternoon of December 23rd.

She is reported by a daughter and her neighbours to have had red spots—apparently petechial in character—on her face, hands,

and legs, and on the last day of her illness she developed a "knot" or swelling, the size of a small hen's egg, on the left side of her neck at the angle of the lower jaw.

An inquest was held and a verdict of "Death due to exhaustion, the results of a weak heart," was returned.

C. R., a daughter, aged 14, was taken ill on December 26th, three days after the death of her mother. She had a dark-red, measly eruption on her face, body, and legs, together with much sickness and diarrhœa. She kept her bed from the first, and complained of a "lump" or swelling, the size of a small hen's egg, at the left angle of the jaw. It was acutely tender, and she screamed if she was touched. Her face was much swollen and her eyes suffused. She was first seen by a medical man on January 2nd, 1910, when she was found with a temperature of 100° , vomiting and abdominal pains and an urticarial rash. On January 5th, the temperature was normal, but on the following day it was 103° and there was then delirium and cyanosis. The rash had vanished. She died next day, January 5th.

A. R., another daughter, aged 9, was taken ill on January 8th, in much the same fashion as her sister. Her temperature ranged from 103° to 104.8° , and she suffered from frequent vomiting. There was no eruption but she, like her sister, is stated, by an elder sister and by a neighbour, to have had a large swelling on the left side of the neck.

On January 10th she was much worse, with vomiting, delirium, and cyanosis, and she died at 5 p.m.

An inquest was held and the viscera were sent to the County Analyst who, however, was unable to discover any vegetable or mineral poison. In his view the result of the examination suggested that the disease was of bacterial origin.

The post-mortem examination showed no very characteristic lesion. The anterior surfaces of the lungs were pitted with ecchymoses varying in size from a millet seed to a pea and a similar condition was observed on the diaphragmatic surface of the pleura. There were 2 oz. of fluid in the pericardium, the left side of the heart was engorged, the right empty. A verdict of "Cause unknown" was returned.

W. G. R., the father, aged 50, was taken ill on the same day as his daughter A. R. (January 8th) was attacked, and his daughter C. R. was buried. At this time he complained of pain in his legs and he was, consequently, unable to walk back from the funeral which he had attended.

When seen next day (January 9th) his temperature was 104° ; he had epigastric pain and suffered from vomiting, and on the following day (January 10th), although the pain was less and the temperature lower, he was still vomiting. But later on, the same day, his temperature was over 103° and the pain worse, and he was admitted to the Ipswich Hospital in the evening.

At the hospital an enlarged inguinal gland was discovered, and his temperature ranged from 103° to 104° . He was drowsy and apathetic, and it was difficult to rouse him.

On January 15th the swelling in the right groin was incised, but there was no pus, and on January 25th the enlarged gland sloughed away. He slowly recovered and was discharged on February 5th.

The case appears to have puzzled all who saw it and no definite diagnosis was made.

On his discharge the patient did not return to his home, but stayed at a house at Nacton (see later).

W. R., a son, aged 12, is said to have been taken ill on January 11th, when he and his brother, J. R. (aged 6), who was then quite well, were removed to Barham Workhouse, near Claydon. It would appear, however, from the evidence, which I procured at the Barham Workhouse, that W. R. had no symptoms of illness on his arrival there. But on January 15th (four days after leaving home) he was taken suddenly ill, with vomiting and diarrhoea and pains in his head, throat, and abdomen. He developed a rash over his abdomen, and was unable to retain his food. His neck was swollen and he complained much of his throat. He was very restless, endeavoured to get out of bed, and his temperature throughout was between 103° and 104° . He got gradually worse and became comatose before his death, which occurred on January 17th.

J. R., aged 6, was, it seems, quite well when he arrived with his brother at the Barham Workhouse on January 11th, and he remained with his brother until he (the brother) was taken ill on January 15th. But on January 18th, *i.e.*, the day following W. R.'s death, he complained of headache and drowsiness, and he was, largely, it seems, as a matter of precaution, sent to the Ipswich Hospital. On admission the patient suffered from headache and presented a heavy, drowsy appearance, and a diagnosis of ptomaine poisoning was arrived at. But his temperature remained practically normal throughout, and on February 9th he returned to Barham Workhouse, leaving there on February 12th for the Children's Home at Grundisburgh.

H. R., a daughter, aged 19, who had remained at home and who had attended to her mother and her two sisters, went to visit her sick brother at Barham Workhouse on Sunday, January 16th, but as the horse which she was driving met with an accident and she was unable to return home, she was taken in by Mrs. F., of Nacton, in whose house she stayed until January 22nd, when, owing to illness, she was taken to the Ipswich Hospital.

According to the evidence obtained by me from the girl herself and from Mr. and Mrs. F. at Nacton, the illness commenced on the night of Thursday, January 20th, with a "sick headache." On January 21st she suffered from vomiting, and on the morning of the following day (January 22nd) she was unable to dress herself without assistance.

On admission to the Ipswich Hospital, she complained of pain in the right groin and in the abdomen, and on January 23rd she vomited at 2 a.m. According to the girl's own evidence she had a swollen face and arms, and the swelling in her left groin burst

in the hospital. On January 27th a purpuric eruption was observed on her legs. On February 2nd she returned to Mrs. F. at Nacton, where, on the following day, she was joined by her father, W. G. R., on his discharge from the hospital.

H. F., aged 7, was the daughter of Mrs. F. of Nacton, who, as already stated, extended hospitality to H. R. on her return from visiting her brother, H. R. at Barham Workhouse on Sunday, January 16th. This child was taken ill on the night on Thursday, February 3rd, when she awoke between 11 and 12 with severe abdominal pain. Next morning (Friday) she was a little better, and remained about the same during the day, but on Saturday morning she became much worse, and medical advice was sought. Her condition grew steadily less satisfactory, and on Sunday was so serious as to indicate the need for an exploratory operation, which was performed at 5 p.m. The child, however, died at 8 p.m. the same night.

The surgeon, who performed the operation, was good enough to furnish me with particulars relative to the case. On opening up the abdomen the omentum and mesentery were full of enlarged glands, varying in size from a pea to a marble; the intestines were inflamed and there was a good deal of lymph thrown out. A post-mortem examination was made and the viscera examined, but no poison was detected. At the inquest a verdict of "peritonitis" was returned.

The surgeon, who performed the operation, is now strongly of opinion, by the light of the subsequent events, that the child was suffering from plague.

The Trimley Outbreak Examined.

The cases of illness here very imperfectly described for lack of reliable data, presented symptoms and manifestations which clearly puzzled all those brought into relation with them, and the inquests which were held and the autopsies which were performed failed to furnish any adequate explanation of the occurrences. All admitted themselves face to face with something which they had not seen before, and which they were unable to classify.

From the accounts of the inquests which I have, through the courtesy of the coroners, had opportunities of studying, it is clear that a toxic condition, brought about either by accidental food poisoning or by the exhibition of some vegetable or mineral poison, was in the minds of many persons at this time.

But the intervals which separated the several attacks of illness and the long period of time—one month—over which the cases cropped up, seems fatal to any such hypothesis, and, moreover, the general circumstances of the outbreak do not in any way fit in with a theory of poisoning.

On the other hand, it would seem that a communicable malady was in question, a fact which is at once apparent by a reference to the foregoing table and a consideration of all the circumstances. In relation to the question of infectivity, whether direct from

case to case or through the medium of some intermediate host or carrier, such as the flea or bug, the fact should be borne in mind that all seven members of the affected family—for presumably not one escaped—were living together in a two-roomed cottage, in one room of which all the inmates slept and, consequently the opportunities for the operation of one or other agencies of infection were numerous. The cases followed one another at intervals of from two to five days, as will be seen by briefly reviewing the evidence.

The first case (H. R.) died on December 23rd, 1909, and the next, that of the girl C. R. was attacked on December 26th. The daughter, A. R., and the father, W. G. R., were attacked on January 8th and 9th, respectively, the previous case (C. R.) having died on January 10th. A. R. died on January 10th and W. G. R. was removed to hospital the same day.

Next day (January 11th) the boys W. R. and J. R. left the infected environment for Barham Workhouse, and four days afterwards, on January 15th, W. R. was attacked and removed from the company of his brother who was attacked on January 18th. Thus far, all the facts fit in with an hypothesis of a communicable disease with short incubative period.

It is necessary to follow the subsequent events rather closely.

The girl H. R. left her home on January 16th, on which day she saw her brother, W. R., at Barham Workhouse. He died the next day. This girl stayed at Nacton until January 22nd, but on January 20th, four days after leaving her infected home and seeing her infected brother, she herself became ill, leaving for the Ipswich Hospital on January 22nd, whence her father had preceded her on January 10th.

H. R. made a good recovery, and on the afternoon of February 2nd returned to the house at Nacton, where she was joined next day, February 3rd, by her father.

At the house at Nacton there lived the child H. F., aged 7 years (a schoolgirl), and she was taken suddenly ill with severe abdominal pains between 11 and 12 o'clock on the night of February 3rd, *i.e.*, some 30 hours after the return of H. R. from the hospital and about eight hours after the return of W. G. R. from the same institution.

The question, therefore, arises as to whether the illness of H. F. could have been due to infection from the girl H. R. or possibly the man W. G. R., both of whom had recently recovered from an attack of the disease which was here in question.

Before considering this point, it will be well to discuss the nature of the illness which attacked the Trimley family with such disastrous results.

A communicable and highly fatal malady was, the evidence indicates, in question, and an hypothesis of this nature is the only one which seems to fit in with all the facts. Moreover, although there are, from lack of full information, many lacunæ

in the story, the balance of evidence certainly seems in favour of a view that the malady was bubonic and septicæmic plague.

Two of the cases admitted into the Ipswich Hospital suffered from inguinal buboes, and several of the other cases are stated by some of those intimately associated with them to have had large painful swellings or "knots," as they were termed, in the neck. The short incubation period, two to five days, the rapidly fatal results, the suffused eyes, and the rashes, together with the buboes, suggest plague rather than any other disease. The only other diseases, which seem on account of their infectivity to call for consideration, are influenza or typhus fever, and these only because of their possible parallel in infectivity. Otherwise, there seems to be nothing in support of this view. The "knots" in the neck of some of the cases might perhaps have been glandular swellings caused by tonsillitis or diphtheria, but the evidence as regards the remaining cases seems sufficient to render this very improbable, and the other inguinal or femoral buboes increase this improbability.

Assuming, therefore, that the Trimley cases were cases of bubonic and septicæmic plague, is it possible to account for the case of H. F. at Nacton in the same fashion. It has already been said that no explanation of the illness was forthcoming at the time, and that the surgeon who performed the operation and found a quantity of enlarged glands in the mesentery and omentum, has, in the light of subsequent events, expressed the opinion that he was dealing with a case of plague.

If, therefore, the Nacton case is best explained on this view, was this case of separate origin, or was it connected with the Trimley series?

I was informed at one stage of my inquiries that dead rats had been observed in the neighbourhood of the house at Nacton about the time of the child's illness, but on visiting the locality I was unable to obtain confirmation of this story, which must be left an open question.

The main point of importance as regards connecting this case with the Trimley series, is whether the interval which elapsed between the return of the girl H. R. from the hospital to Nacton and the occurrence of the symptoms in the case of H. F. was sufficiently long to justify an association of the two events as cause and effect. The period was certainly below the average incubation period of plague, but in Volume V. of the Report of the Indian Plague Commission, which was issued in 1901, several instances are furnished where the incubation period was 1 to 1½ days. In one instance the period was 8 hours, in another 24 to 36 hours. Dealing with these facts, the report states that plague may develop, possibly, within 24 hours, certainly within 48 hours after exposure to infection. "Several instances of incubation periods, not exceeding 24 hours, are, we may note, recorded in connection with Mahamurrie in Kumasie."

There is one other point which must be referred to, and that is the question as to whether H. R. may have infected H. F.

before she, H. R., left for the hospital on January 22nd, and at a time when she was actually ill. This would involve an incubation period of 12 days. It may be said at once that this interval is too long, except in the very unlikely event of the disease having taken the form of what is known as *pestis minor*, and then, owing to some sudden loss of resisting power on the part of the patient, developing into typical plague. But in this instance there is no evidence whatever in support of this view.

Reverting now to further consideration of the whole group, the difficulty which presents itself is as to the channel or agents by which the disease spread from person to person.

Bubonic plague is a disease which, so far as is known at present, spreads from rat to man by the agency of the rat flea and not otherwise, and upon this assumption there is considerable difficulty in accounting for the whole of the present series of cases. It was not possible to ascertain that any dead rats had been heard of in the neighbourhood of the invaded houses at Trimley, but, on the other hand, it may be confidently stated that plague amongst rats was extensively spread over many parts of the Woodbridge union, which comprises Trimley, and rats, dead of plague, were found in Trimley parish in the autumn of 1910. It requires, therefore, no great stretch of the imagination to suppose that plague rats may have existed at Trimley during the time of the outbreak of illness with which we are now dealing, and that such rats may have obtained access to the house or to some of the outhouses connected therewith. On this assumption, the cases which arise in the house may have been due, each one, to rat-flea infection, or there may possibly have been some transference of infected rat fleas from case to case.

It is, too, by no means inconceivable that in the series of cases *Pulex irritans* may have been the agent by means of which infection was transmitted from case to case.

Although the experience in India as regards bubonic plague is opposed to the communicability of the disease from case to case, the behaviour of the disease in this country in past epidemics raises the question whether case to case infection does not in some outbreaks manifest itself even with bubonic and septicæmic plague. Moreover, the remarkable experiments which were conducted by Dr. Verbitski* in 1902-3, at Cronstadt and St. Petersburg, show conclusively that *Pulex irritans* may live as a casual parasite on rats, and that the stomach of these fleas may contain plague bacilli.

Dr. Verbitski found that human fleas and fleas found on cats and dogs are able to live on rats as casual parasites, and, therefore, that they can under certain conditions play a part in plague transmission from rats to human beings and *vice versa*.

Verbitski also showed, by his experimental work, that it was probable that, in addition to the direct part which infected insects can play in the spread of plague, the belongings and especially

* "Journal of Hygiene," Vol. 8, No. 2, May, 1908. Fourth Extra Number containing Reports on Plague Investigations in India.

the linen of patients soiled by the fæces of infected insects or by their crushed bodies can serve as a possible source of infection during a considerable time.

These experiments are not without importance in reference to the series of cases here being considered, and they may help to explain the infection of the child H. F. by the girl H. R. after her discharge from hospital.

Had these Trimley cases been cases of pneumonic plague, the explanation as regards communicability would have been quite obvious; and it is, of course, possible that in some of these cases there may have been pneumonia which was unrecognised.

THE SHOTLEY OUTBREAK.

Account of an outbreak of Fatal and Infectious Pneumonia which occurred at Shotley in the Samford Rural District in December, 1906, and January, 1907.

The Freston outbreak had the effect of again attracting attention in somewhat significant fashion to the fatal outbreak of illness which occurred at Shotley in the winter of 1906-7.

The house in which the first family invaded in this outbreak resided was one of two cottages known as Charity Farm Cottages, which are situated some three-quarters of a mile north of Shotley Church, and about the same distance south of the Orwell estuary (*see E on map*).

The family living in the invaded cottage consisted of about eight persons, mostly relatives, and the following table, which, however, is not quite complete, from lack of information, furnishes some general idea of the succession and relationship of the several cases involved in the whole of this outbreak:—

Initials.	Age.	Sex.	Date of Attack.	Date of Death.	Date of Burial.
Mrs. C. ...	53	F.	Dec. 9, 1906	Dec. 12 ...	Dec. 17.
Mrs. R. (daughter of Mrs. C.).	24	F.	Dec. 17, 1906	Dec. 19 ...	Dec. 22.
E. C. ...	19	F.	Dec. 20, 1906	Recovered.	
Mrs. J. G. ...	46	F.	Dec. 24, 1906	Dec. 26 ...	Dec. 29.
Mr. Will. G. ...	56	M.	Dec. 28-29 ...	Jan. 2 ...	Jan. 5.
Reginald G. ...	7	M.	Dec. 30 ...	Jan. ...	Jan. 5.
Herbert G. ...	—	M.	Dec. 27 ...	Recovered.	
Mrs. W. (Mrs. G.'s mother).	—	F.	Jan. 3 ...	Jan. 6 ...	Buried at Sax- mundham.

Dealing now in detail so far as is practicable with the data available, the following facts emerge—

Mrs. C., aged 53, was taken ill on the night of December 9th-10th with symptoms of acute pneumonia, and died on December 12th, after two days illness.

Mrs. R., aged 24, a married daughter of Mrs. C., living only a few yards away, and who had nursed her mother, developed the disease on December 17th. She died on December 19th.

E. C., aged 19 (another daughter of Mrs. C.), who had nursed her mother and also Mrs. R., was taken ill on December 20th, but recovered.

Mrs. G., aged 46, a neighbour living in a row of cottages (see F on map) a short distance away, nursed E. C., and was taken ill on December 24th. She died on December 26th.

Mr. G., aged 56, who nursed his wife, was attacked on December 28th-29th, and died on January 2nd.

H. G., aged 7 (a son), was attacked on December 27th, and recovered, and R. G., his brother, was attacked on December 30th and died on January .

Mrs. W. (Mrs. G.'s mother), who lived in another part of Suffolk, went to her daughter's funeral on December 29th, and stayed on in order to nurse Mrs. C. and look after the family generally. She manifested symptoms of the disease on January 3rd (the day after the death of her son-in-law), and she died on January 6th, after three days illness. She was buried at Saxmundham.

The woman who was first attacked is stated by Dr. Carey, of Holbrook, who attended all the cases, not to have been in Ipswich for two years, and it is not possible after this lapse of time to ascertain in what manner she became infected. At the time of her illness one son was away on the estuary of the Deben with a barge, and the sweetheart of one of the sisters lived in the same house and worked as a labourer in Shotley Naval Barracks.

While making investigation into the above series of cases I heard of the occurrence of several cases of pneumonia at the barracks in question during the year 1906. Accordingly I conferred at Shotley Barracks with Fleet-Surgeon Batley Brown, R.N., who finding, on looking up the cases that the records were at the Admiralty, was good enough to communicate with Fleet-Surgeon Clayton, R.N., who very kindly made a complete analysis of all the cases of pneumonia in the barracks during several years. From this carefully prepared record and from other evidence it is clear that there was no connection between the barrack cases and those which occurred at Charity Farm Cottages.

The barrack cases did not occur in sequence suggestive of communicability, and they took the usual form of ordinary lobar pneumonia. There was no history of any communication between the inmates of the invaded houses and the cases of pneumonia which occurred at the barracks.

This is the view which was also arrived at by Dr. Carey, the medical attendant of the extra-barracks cases, by Dr. Elliston, the medical officer of health, and by the Rev. John Hervey, the rector of the parish, who had taken much interest in the matter, and who abstracted for me from the church registers the records of burials at and about the period in question.

The family first invaded were in poor circumstances and the house was somewhat overcrowded, and in both these respects the Freston and Shotley conditions were similar. Obviously, however, these circumstances are not unlikely to be common factors when dealing with the poorer classes.

But the two outbreaks resemble one another in the fact that one house only was primarily invaded, the members of the remaining houses being obviously infected by nursing the sick in the first invaded house.

Similarly there was manifested in both outbreaks high infectiveness, a short incubation period, and, perhaps more especially, a rapidly fatal issue in a large proportion of the cases.

It may perhaps also be observed that there is evidence pointing to an undue mortality amongst rats and hares in the locality on each occasion, and that those who had to do with the Shotley outbreak are now of opinion, in view of the subsequent developments, that pneumonic plague was then in question.

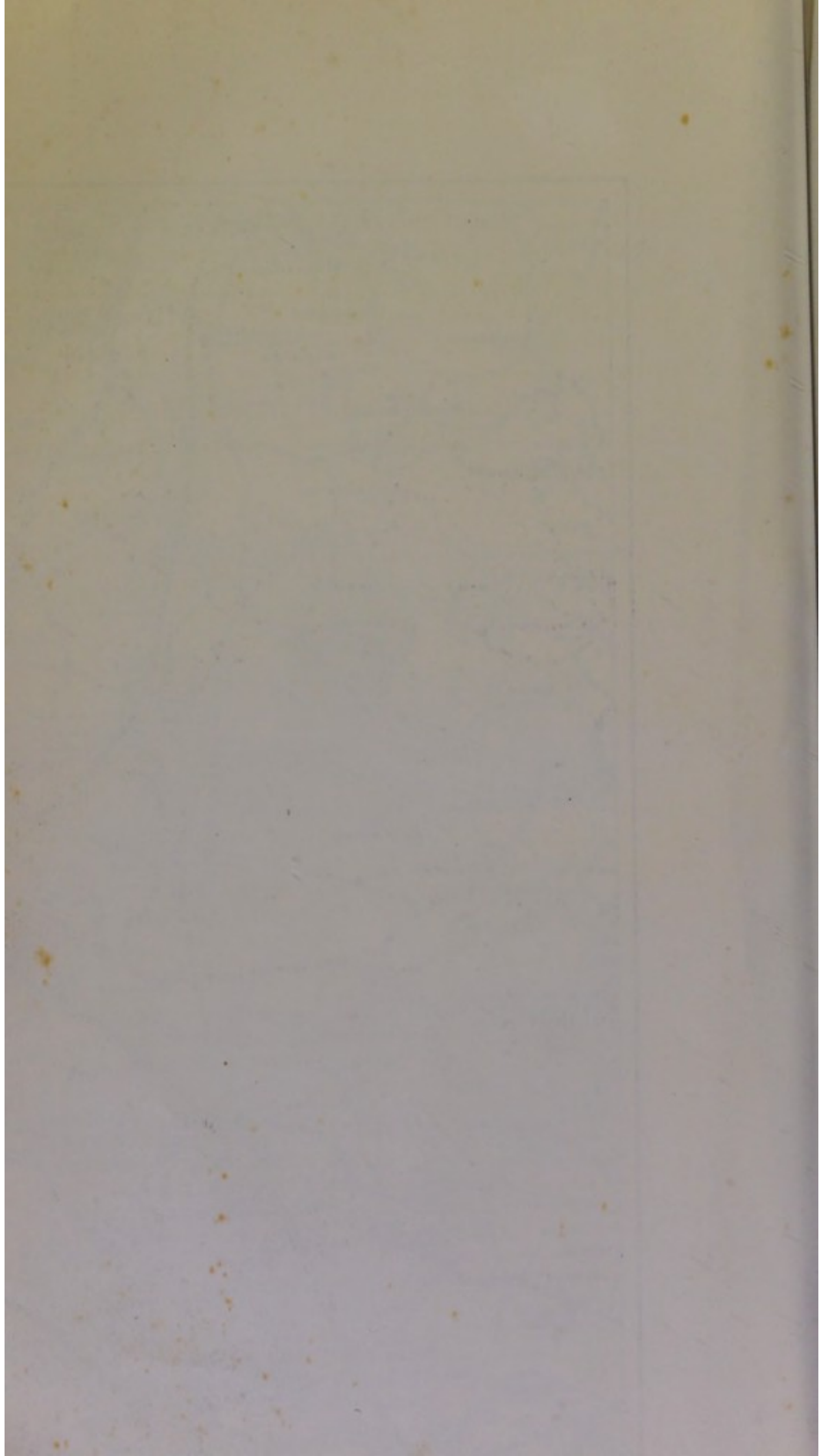
It has, however, to be pointed out that influenza was prevalent in the Shotley district about that time, and the cases were then believed to have been due to a virulent form of the disease. But the rapidly fatal character of the outbreak certainly raises the issue as to whether the manifestations did not more closely resemble pneumonic plague than did influenza.

H. TIMBRELL BULSTRODE.

[illegible]

H. TROMPER, BERNING





II.

Observations on Rat Plague in East Suffolk, November and December, 1910, by C. J. Martin, M.B., D.Sc., F.R.S., Director of the Lister Institute of Preventive Medicine, Member of the Advisory Committee for the Investigation of Plague in India; and Sydney Rowland, M.A., M.R.C.S., of the Lister Institute of Preventive Medicine, Member of the Commission for the Investigation of Plague in India.¹

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Shortly after the occurrence of cases of pneumonic plague at Freston in September last, an unusual mortality amongst rats was observed at Freston Wood, and a dead specimen which was forwarded by the Local Government Board to Professor Klein was discovered to be infected with plague. Henceforth the attention of the sanitary authorities in the neighbourhood was directed towards discovering any extraordinary mortality amongst rats, and a number found dead were bacteriologically examined by Professor Klein and Dr. Heath. By this means it was demonstrated, during the next six weeks, that rats were infected with plague over a considerable area between Ipswich and the sea coast.

(¹) The services of Mr. Rowland were placed at the disposal of the investigation for 14 days by the courtesy of the Advisory Committee for the Investigation of Plague in India.

In addition, a couple of hares, one from Mistley and another from as far west as Edwardstone, were proved to have died of the disease.

The whole circumstances of the outbreak of rat-plague were under investigation by the Local Government Board, and the portion of the enquiry dealing with the nature, habits, and parasites of the rats in this district was assigned to us. Incidentally, however, we secured, in certain localities, a good many live rats which were found to be infected with plague. The discovery of these rats, together with information gleaned from local sources, and the observations of Dr. Heath and Professor Klein, enable some estimate of the extent and severity of the epizootic to be formed.

Our first series of observations extended over 14 days, from the 8th to the 22nd of November. On December 27th we again visited the district and spent six days at Hollesley Bay. This locality showed every indication of being heavily infected when we were there early in November, and we wished to ascertain what changes, if any, had taken place with the onset of the cold weather, both with regard to the distribution of the rat population and to the prevalence of the disease amongst them. Further, it was the only locality where we had discovered a plague-infected rabbit, and it seemed advisable to pursue the enquiry in this direction.

For the invaluable help we received from the medical officers to the Board, from Dr. Heath, county medical officer, Dr. Pringle, M.O.H. for Ipswich, and also from the various proprietors upon whose land we worked, we wish to tender our best thanks.

METHOD OF ENQUIRY.

The necessary laboratory equipment was conveyed to the scene of operation in a small motor car.

The rats were obtained by trapping over night and ferretting during the day. Immediately after killing, they were placed in large tins containing chloroform vapour to anæsthetise the fleas and facilitate their capture. As each tin was filled, it was brought to an extemporised laboratory in some barn or outhouse near by.

Each rat was first examined for fleas. They were counted and, after a provisional examination, reserved for future identification. The rat was then dissected and examined for any naked eye appearances of plague, *e.g.*, buboes, subcutaneous injection, or hæmorrhage from small vessels, peculiar mottling of the liver, enlarged spleen, and pleural effusion. If, from the above examination, there was any reason to suspect plague infection, microscopical preparations were made from the enlarged glands, and from the organs, and examined forthwith for the presence of *B. pestis*. If the post-mortem and microscopical examination were so characteristic as to leave no doubt that the animal was infected with plague, cultures from the organs were not necessarily taken. Cultures were, however, taken from at least one of the rats diagnosed as plague-infected in each locality; these were submitted to cultural tests and inoculated into animals

(rats and guinea-pigs). It will conduce to brevity if we say that every provisional diagnosis of plague by post-mortem and microscopical examination was confirmed in those cases in which further cultural examination was made.

There were a few rats which, from post-mortem appearances, we considered to be cases of "recovering plague,"⁽¹⁾ but in which we failed to discover *Bacillus pestis* by microscopical examination. From some of these we succeeded in cultivating the organism, and reproducing the disease in rats.

LOCALITIES INVESTIGATED.

The area within which the observations were made is indicated in the accompanying outline map. It is included in a polygon roughly bounded by the River Orwell, the sea coast from the mouth of the Orwell to Orfordness, and by lines from Orfordness to Woodbridge, Woodbridge to the village Boulge, and thence west to Claydon, and south to Copdock and Ipswich.

It included parts of the rural districts of Woodbridge, Bosmere, and Claydon, and the borough of Ipswich.

The choice of the particular estates examined was, with the exception of Farm C, Nacton, and a Labour Colony in the Woodbridge Union, determined by the facilities afforded us by the owners and not by the previous discovery of rat plague in the locality. The places investigated were Farm A, Culpho; Farm B, Culpho; Farm C, Nacton; Farm D, Boot Street; the Labour Colony already referred to; Farm E; Farm F, Nacton; Farm G, Stratton; Farm H, Morston; Farm I, Borough of Ipswich; Farm J, Westerfield, Ipswich; Farm K, Ipswich; Farm L, Outskirts of Ipswich; Farm M, Ipswich; Farm N, Alston; Farm O, Akenham; and Farm P, Claydon.

THE SPECIES OF RATS.

With the exception of a few water rats (*Arvicola amphibius*) all the rats examined by us were of the species *Mus decumanus*. We made numerous enquiries as to the existence of the black rat (*Mus rattus*) from rat-catchers and keepers, but this species was unknown to them. I am informed, however, by Dr. Pringle, M.O.H., Ipswich, that he has lately seen one individual taken at the Ipswich Dock and presumably reimported into the locality by shipping.

We examined 568 *Mus decumanus* in November and 151 in December.

PARASITES UPON THE RATS.

The material for this portion of the enquiry was obtained by collecting the insects actually infesting the rats at the time of examination and also from six rats' nests which were dug out of banks. Three nests were obtained from Suffolk, two from Elstree in Hertfordshire, and one from Romsey in Hampshire. These latter observations are of interest as they indicate that

⁽¹⁾ *Vid.* Reports of Commission for Investigation of Plague in India "On the Natural Occurrence of Chronic Plague in Rats," *Journ. of Hyg.*, Vol. 7, p. 457; and "Resolving Plague in Rats," *Journ. of Hyg.*, Vol. 10, p. 335.

the fauna parasitic upon the rats living in the open country is much the same in these widely separated parts.

Before removing the fleas they were lightly anæsthetised with chloroform by placing the animals or nests in a tin with some of the vapour.⁽¹⁾ Fleas are very susceptible to chloroform. As might be expected from their small mass they are rapidly brought under the influence of the vapour, but, in addition, they are a very long time in recovering from the effects. The latter peculiarity renders their manipulation easy and affords ample time for a lengthy microscopical examination, without which they cannot be identified.

The principal parasites of the rats were fleas. Some ticks and lice were also found. The ticks and lice have not yet been identified, but the fleas were almost entirely of two species.

From 568 rats examined in November we obtained 584 fleas. The number per rat varied from 0 to 10, except in the case of one rat from which 30 fleas were captured.

Of the 584 rat fleas 324 were *Ceratophyllus fasciatus*, and 259 were *Ctenophthalmus agyrtes*, and one *Ctenophthalmus bisoctodentatus*.⁽²⁾

Table I. gives the numbers and species of fleas obtained from nests in December. The nests were in burrows in the ground, except the one from Romsey, which was found at the bottom of some hay in a barn. They were occupied by rats at the time they were discovered.

TABLE I.
Number of different kinds of Fleas found in Rats' Nests.

Locality where found.	Date.	<i>Cerato- phyllus fasciatus.</i>	<i>Ctenoph- thalmus agyrtes.</i>	<i>Hystri- chopsylla talpæ (Giant flea).</i>
Nest No. 1 Suffolk	30/12/10	53	88	—
" 2 "	31/12/10	32	9	—
" 3 "	31/12/10	16	17	1
" 1 Elstree	7/12/10	34	124	—
" 2 "	1/1/11	52	48	1
" Romsey	29/12/10	2	4	—
		189	290	

We have not found *Xenopsylla cheopis* (formerly *Pulex cheopis*), which is the flea infesting the rats in India, where upwards of 99 per cent. of all fleas taken off rats were of this species.⁽³⁾ *Xenopsylla cheopis* is also the preponderating rat flea in Sydney, Brisbane⁽⁴⁾ and Manila.⁽⁵⁾ It also formed a large proportion

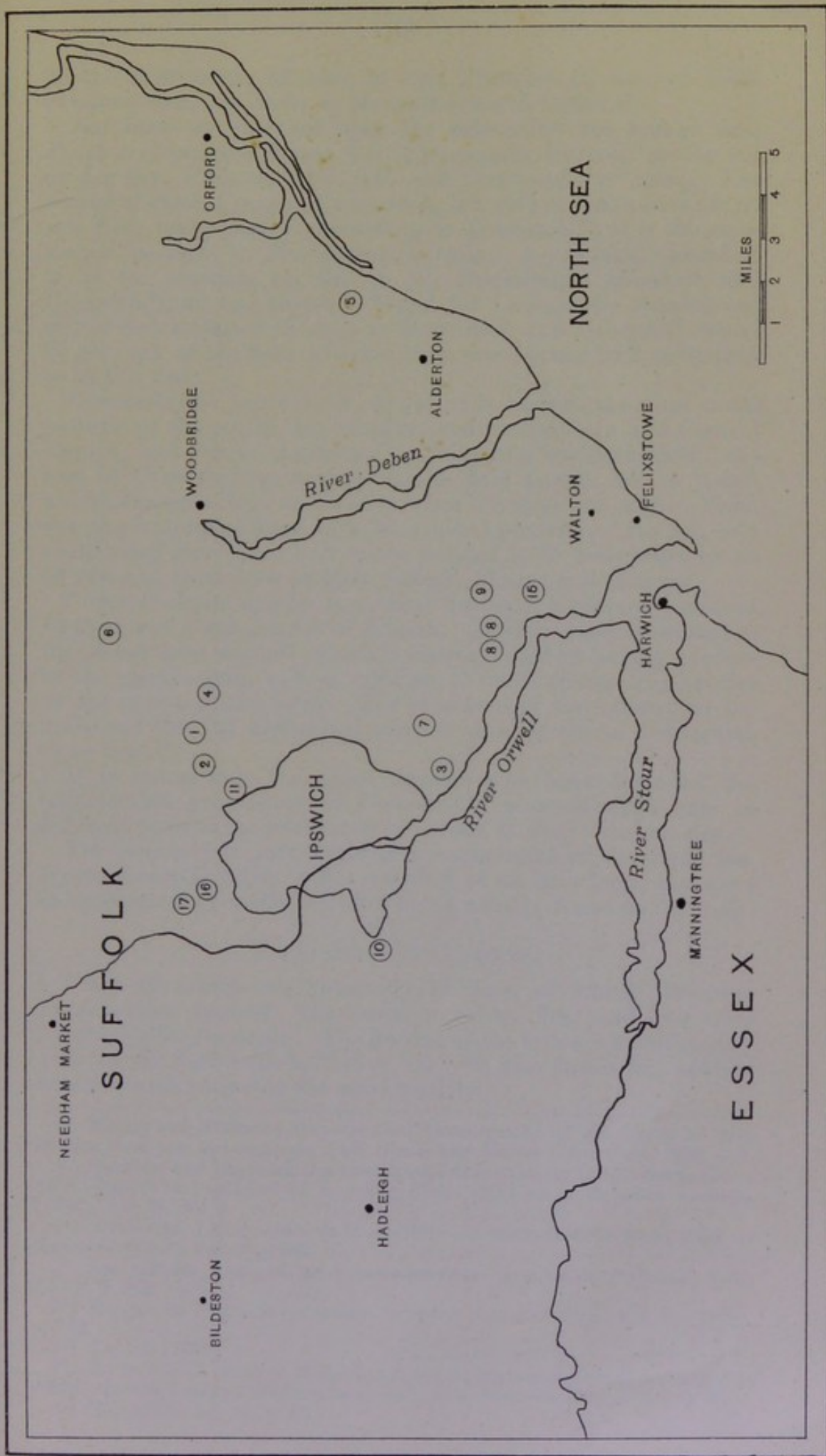
(1) Cf. Reports of Commission for Investigation of Plague in India, *Journ. of Hyg.*, Vol. 8 (1908), p. 256.

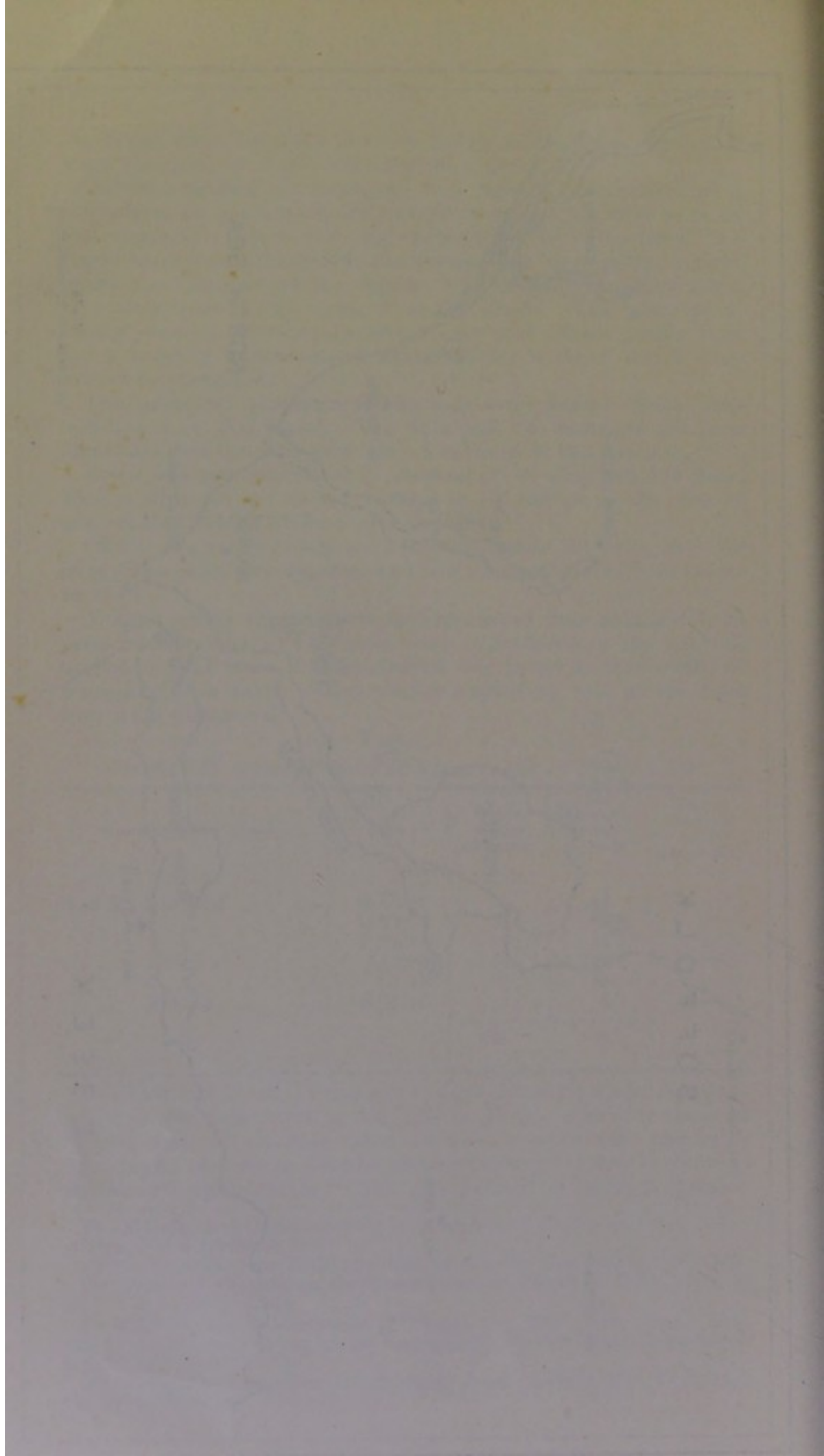
(2) The fleas have been kindly identified for us by the Hon. Charles Rothschild.

(3) Reports of Commission for Investigation of Plague in India, *Journ. of Hyg.*, Vol. 7 (1907), p. 914.

(4) Tidswell, the Epidemiology of Plague, &c., *Brit. Med. Journ.*, 1903, Vol. 1, p. 1,491, and Report of the Government Microbiological Department, N.S.W., 1910, p. 20.

(5) Herzog, Zur Frage der Pestverbreitung durch Insekten, *Zeitschr. f. Hyg.*, Vol. 51 (1905), p. 268.





of the fleas taken off rats in San Francisco,⁽¹⁾ and of those obtained from the docks at Marseilles⁽²⁾ and Genoa.⁽³⁾

Nor have we captured upon the rats either the human flea, *Pulex irritans*, the mouse flea, *Ctenopsylla musculi*, or the cat or dog flea, *Ctenocephalus felis* and *Ctenocephalus canis*. The second of these, *Ctenopsylla musculi*, is a very common parasite on rats from many parts. According to Tiraboschi⁽⁴⁾ it is the commonest parasite on *Mus rattus* in Italy. Verbitski⁽⁵⁾ found it to be the common rat flea in St. Petersburg. Gauthier and Raybaud⁽⁶⁾, on one occasion, found 178 *Ctenopsylla musculi* out of 250 fleas captured off ships in Marseilles, and Tidswell⁽⁷⁾ found 25 per cent. of the fleas collected from rats during 1909 in Sydney to be this flea.

Ceratophyllus fasciatus is, as far as is known, the most usual parasite of the rat in this country, and in Northern and Central Europe, and North America.⁽⁸⁾ According to Rothschild, the host of *Ctenothalmus agyrtes* is the field mouse, but it is not uncommon upon *Mus decumanus* when living in the open. From our observations it appears to be a usual parasite of the rat, and contributed more than half to the total of 1,065 fleas taken by us off rats and from nests in East Suffolk, Elstree and Romsey.

Ctenophthalmus agyrtes is a blind flea with a thoracic comb of 16 teeth and a genal comb of 3 teeth. It may easily be mistaken for *Ctenopsylla musculi*, which is distinguished by having 4 spines in the genal comb, and in addition 2 small spines like bristles on the crown of the head. The structure of the clasper on the male and the 7th abdominal sternite also serves to distinguish these fleas.⁽⁹⁾

It is conceivable that some authors who have described the considerable prevalence of *Ctenopsylla musculi* upon rats in different parts of the world may have been dealing with this flea.

The discovery in rats' nests of two specimens of the giant flea, *Hystrihopsylla talpæ*, a flea one-fifth of an inch long, is a mere entomological curiosity, this flea being usually found on the mole.

FLEAS FOUND ON RABBITS.

From 40 rabbits we obtained 115 fleas, of which 113 were *Spinopsyllus cuniculi*, the common rabbit flea, and two were *Ceratophyllus fasciatus*. The finding of the latter is significant in view of the fact reported below that we also found two rabbits infected with plague in the same locality.

(1) McCoy and Mitzmain, Experimental Investigation of the biting of man by fleas from rats and squirrels, *Pub. Health and Marine Hosp. Serv.*, 1909, p. 5.

(2) Gauthier and Raybaud, Recherches expérimentales sur le rôle des parasites du rat dans la transmission de la peste, *Revue d'hygiène et de police sanitaire* (1903), Vol. 25, No. 5.

(3) Tiraboschi, L'état actuel de la question du véhicule de la peste, *Arch. de Parasitol* (1907), Vol. 2, p. 583.

(4) Les rats, les souris et leurs parasites cutanés, *Arch. de Parasitol*, 1904, Vol. 8, p. 282.

(5) Reports on Plague Investigation in India, *Journ. of Hyg.*, Vol. 8, (1908), p. 162.

(6) *Loc. cit.* (1903).

(7) *Loc. cit.* (1910).

(8) Rothschild, A synopsis of the fleas found on *Mus norvegicus decumanus*, *Mus rattus alexandrinus* and *Mus musculus*, *Bull. Ent. Research*, 1910, Vol. 1, p. 97.

(9) Rothschild, *loc. cit.*, p. 89.

EXPERIMENTS TO DETERMINE WHETHER THE FLEAS FOUND ON RATS IN SUFFOLK, *Ceratophyllus fasciatus* AND *Ctenophthalmus agyrtes*, AND ON RABBITS, *Spilopsyllus cuniculi*, BITE MAN.

In view of the evidence that the epidemic spread of bubonic plague in India is due to the infection of man by rat fleas⁽¹⁾ which have previously fed upon plague-stricken rats, the question of the appetite for human blood of the two fleas infesting these animals in Suffolk is one of first-rate epidemiological importance.

The fact that *Xenopsylla cheopis*, the almost universal rat flea of India, will bite man was shown by Tidswell⁽²⁾ and Gauthier and Raybaud.⁽³⁾ That it readily feeds on man, and, in the absence of its natural host, is attracted to mankind, was demonstrated by Liston⁽³⁾ and abundantly established by the Commission for the Investigation of Plague in India.⁽⁴⁾

With regard to the readiness with which *Ceratophyllus fasciatus* attacks man, however, considerable divergence of opinion exists, and no experiments have hitherto been made with *Ctenophthalmus agyrtes*.

According to Wagner,⁽⁵⁾ Tiraboschi⁽⁶⁾ and Galli-Valerio,⁽⁷⁾ *Ceratophyllus fasciatus* does not bite man. On the other hand, Tidswell,⁽⁸⁾ Gauthier and Raybaud,⁽⁹⁾ McCoy and Mitzmain⁽¹⁰⁾ found that, when hungry, it fed on man with readiness.

Some hundreds of experiments have been made on this question by Dr. Harriette Chick and one of us,⁽¹¹⁾ and we are at a loss to understand the negative conclusion arrived at by Tiraboschi and Galli-Valerio. Starved for 24 hours or longer, 60 per cent. of the individual fleas, when placed upon the naked skin of ourselves and our friends, have fed within two minutes. The whole process can be watched with a pocket lens, as once having entered its pricker, the flea remains quiescent for two to five minutes, during which time his stomach can be seen to become distended with blood. In most individuals the puncture leaves little or no mark, and produces no irritation, but with some persons red raised papules occur, which itch and last two or three days, as may be seen from the photograph attached to this report.

Our experiments with *Ctenophthalmus agyrtes* are much fewer in number, as we have not yet had time to breed a supply of these

(1) This evidence is set forth in the Reports of the Commission for the Investigation of Plague in India. The experiments of the Commission appeared as special numbers of the *Journ. of Hyg.*, Vol. 6, No. 4 (1906); Vol. 7, No. 3 and No. 6 (1907); Vol. 8, No. 2 (1908). In Vol. 6, pp. 425-434, will be found an epitome of the literature regarding the transmission of plague by fleas at the time of the publication of the earlier work of the Commission.

(2) 1903, *loc. cit.*

(3) Plague, Rats and Fleas, *Journ. Bombay Medical Soc.*, 1904.

(4) Report, *Journ. of Hyg.*, Vol. 7 (1907) p. 472, and Vol. 8 (1908), p. 249.

(5) Quoted by Tiraboschi, *loc. cit.*, 1904, p. 180.

(6) *Loc. cit.*, 1904, p. 266.

(7) L'état actuel de nos connaissances sur le rôle des puces dans la transmission de la peste bubonique, *Central f. Bakt.*, Vol. 39 (1907), p. 729.

(8) Report on Board of Health on second Outbreak of Plague at Sydney in 1902, published 1903.

(9) *Loc. cit.*, 1903, and la puce du rat (*Ceratophyllus fasciatus*) pie l'homme, *Comptes Rendus, Soc. de Biol.*, Vol. 67 (1909), p. 859.

(10) *Loc. cit.*, 1909.

(11) This subject will be treated in greater detail in a paper to appear shortly in the *Journ. of Hyg.*



Arm of A. M. 40 hours after 30 specimens of Ceratophyllus fasciatus had been placed upon it, one at a time. 24 of these were seen to bite.

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fleas. Our observations are confined to 70 experiments upon four persons. We can, however, say that, under conditions in which it readily bites rats, we have observed no inclination on the part of this flea to feed on man.

The following experiment illustrates the difference in the behaviour of the two kinds of flea. A bottle containing 23 fleas, which had fasted three days, some *Ceratophyllus fasciatus*, others *Ctenopthalmus agyrtes*, was inverted upon the arm of one of us (S. R.) for two minutes. During this time several fleas were felt to bite. At the end of the two minutes those fleas not attached to the skin were shaken back into the bottle. Eleven remained feeding, and after allowing a few more minutes for the completion of their repast, they were chloroformed, examined, and identified. The whole 11 were full of blood, and were all *Ceratophyllus fasciatus*.

The remaining 12, which did not feed upon S. R., were placed upon C. J. M. Only one fed, which was identified as a *Ceratophyllus fasciatus*. The 11 still remaining were examined and found to consist of eight *Ctenopthalmus agyrtes* and three *Ceratophyllus fasciatus*. We are not in a position to state that under no circumstances a small percentage of *Ctenopthalmus agyrtes* may not feed on man. The matter will be more fully investigated when, by breeding the insects, a reasonable supply of individuals for experiment is secured.

The smell of man appears to stimulate and attract *Ceratophyllus fasciatus*. When the hand is placed over a bottle containing them they jump about and display unusual activity, and when a hand was placed in a rat's nest, the rats from which had been destroyed the day before, a number of fleas of this species immediately jumped on to the hand, and the majority fed.

Similar operations were made with flea cages. These consist of glass boxes in which the fleas are bred, and in one compartment of which, separated by a coarse wire netting, a rat lives. On placing the hand and arm in such a cage containing a large number of *Ceratophyllus fasciatus*, as many as 40 fleas have hopped on to the arm and attached themselves, notwithstanding the presence of a rat within six inches.

It is certain, therefore, that *Ceratophyllus fasciatus* evinces no distaste for humans, but feeds upon them readily in the absence of its natural host. *Ctenopthalmus agyrtes*, on the other hand, does not, as far as can be ascertained, bite man.

We have only been able to make a few experiments with rabbit fleas, *Spilopsyllus cuniculi*, but have been informed that it is not an unusual experience to be bitten by them when handling fresh caught rabbits. Our own observations are limited to nine specimens, which were the only survivors of those we brought from the Labour Colony. These fleas had been starved for two days. When placed for two minutes upon the arm of one of us (S. R.), two bit at once. The remaining 7 were placed on C. J. M.; one fed. As a control, the six non-feeders were then placed on the inside of a rabbit's ear. They ran about in a lively manner, but during the five minutes they were under observation did not feed. The experiment indicates that those individuals which would not feed upon us were presumably not hungry, as they did not bite their natural host.

THE FLEA PREVALENCE.

The importance of flea prevalence in determining the outbreak of the rat epizootic, both under experimental and natural conditions, and also the spread of the disease to man has been pointed out by the Commission for the Investigation of Plague in India.⁽¹⁾ Flea infestation is indeed the only factor the Commission has so far been able to discover to be correlated with plague outbreaks, and to be capable of interpreting the striking seasonal prevalence of the disease in different parts of India. In Bombay, Poona, the Punjab, and Belgaum, notwithstanding the widely differing type of climate possessed by these places, the season at which plague epidemics occur is well defined. The epidemic season in the different localities does not coincide, but in every case occurs during some portion of that period of the year, differing in different localities, in which a decided increase (as much as six times) in flea prevalence obtains.⁽²⁾

In Table II., in which many of the observations made by us are succinctly summarised, it will be seen that the number of fleas per rat varied from 0·1 to 3·3 in the different localities, and was on the average one flea per rat. The number of rats examined is insufficient to permit of any important conclusion being drawn from such a census, but it may be noted that the greatest number of fleas was taken from samples of rats from districts which showed the largest proportion of plague infected animals.

The number of fleas per rat was, compared with the experience of the Indian Commission, low. In the Punjab the number of *Xenopsylla cheopis* per rat varied, according to the time of year, from 2 to 12·6, in Bombay from 2 to 7, in Belgaum from 3·6 to 18·6, and in Poona from 1 to 11.⁽³⁾

In considering the influence of flea prevalence as a factor in the spread to man of the plague existing amongst rats in East Suffolk, it must be remembered that as *Ctenophthalmus agyrtus* does not seem to bite man, the effective prevalence in East Anglia is only about one-half of the total, viz., 0·5 fleas per rat. This is an infestation which was not found sufficient to give rise to a human epidemic in India, notwithstanding the vastly greater accessibility of mankind for rat fleas.

It must not, however, be lost sight of that our observations were made in November, after the onset of cold weather, and that at this season of the year the rate of breeding of fleas is at a minimum if not entirely negligible.

FLEAS FOUND INFECTED WITH *B. pestis*.

Ogata,⁽⁴⁾ Buchanan⁽⁵⁾ and Liston⁽⁶⁾ observed enormous numbers of *Bacillus pestis* in the stomachs of fleas from infected rats.

(1) *Journ. of Hyg.*, Vol. 6 (1906), p. 446; Vol. 7. (1907), pp. 429 and 445; Vol. 8 (1908), p. 295.

(2) Report of the Commission for the Investigation of Plague in India, *loc. cit.* (1908), p. 266, and *Journ. of Hyg.*, Vol. 10 (1910), pp. 460 and 524.

(3) Report, *loc. cit.* (1908), pp. 297 and 298, and (1910), pp. 461 and 524.

(4) Über die Pestepidemie in Formosa, *Centr. bl. f. Bakt.*, Vol. 21 (1896), p. 774.

(5) *Seventh Annual Report, L.G.B. for Scotland* (1902), p. 73.

(6) *Loc. cit.* (1904).

The Plague Commission⁽¹⁾ found that 50 per cent. of the fleas taken off rats dying of plague, and 30 per cent. of those examined from some Indian houses where cases of plague had occurred, contained in their stomachs numerous plague bacilli. The number of organisms was often so greatly in excess of the quantity contained in the septicæmic blood of rats that active growth had evidently taken place.

We examined the contents of the stomach of three fleas captured off a rat which was proved to be infected with plague. The stomachs⁽²⁾ of two out of the three fleas contained, in considerable numbers, bacilli microscopically indistinguishable from plague. The fleas were two *Ceratophyllus fasciatus* and one *Ctenopthalmus agyrtes*. Unfortunately, it was not noted at the time to which of the three fleas the infected stomachs had belonged.

NUMBER AND PROPORTION OF RATS FOUND TO BE INFECTED AND THE LOCALITIES FROM WHICH THEY WERE DERIVED.

The results of our observations under this heading are set forth in Table II. below:—

TABLE II.

A. Results on Examination of Rats and their Parasites.

No.	Date 1910.	Locality.	No. captured.	No. of fleas secured.	No. of fleas per animal.	No. of animals infected.
1	Nov. 8	Farm A. Culpho	39	119	3.0	4
2	" 9	" B. "	21	19	.9	1
3	" 10, 11	" C. Nacton	49	98	2.0	5
4	" 12	" D. Boot St.	33	41	1.2	0
5	" 13	Labour Colony in Woodbridge Union.	35	116	3.3	5
6	" 14, 15, 16.	Farm E. Thistleton	113	71	.6	1
7	" 17, 18	" F. Nacton	83	31	.2	0
8	" 18	" G. Stratton	32	23	.7	0
9	" 18	" H. Morston	13	6	.5	0
10	" 14	" I. Boro' of Ipswich } 2 miles out.	5	—	—	1
11	" 19	" J. Westerfield } Via Dr. Boro' of Ipswich. } Pringle, 2 miles out. } M.O.H.	12	6	.5	0
12	" 19	" K. Boro' of Ipswich, 2 miles out.	13	7	.5	0
13	" 20	" L. Outskirts of Ipswich Boro'	9	6	.7	0
14	" 20	" M. (Near Railway Station) Ipswich.	2	0	—	—
15	" 19	" N. Alston	43	25	.6	0
16	" 20	" O. Akenham	33	10	.3	0
17	" 20	" P. Claydon	33	6	.2	0
Totals			568	584	—	17
(5)	Dec. 29, 30, 31. Jan. 2.	Labour Colony	151	—	—	3

B. Results on Examination of Rabbits.

(5)	Nov. 13	Labour Colony	5	31	6.0	1
	Jan. 2-11	"	35	84	2.3	1
Totals			40	115	—	2

⁽¹⁾ *Loc. cit.* (1906), p. 481, and (1907), p. 398.

⁽²⁾ Notwithstanding careful searching, bacillus pestis was never found by the Indian Commission outside the alimentary tract of *Xenopsylla cheopis*. (*Loc. cit.* (1907), p. 406.)

We would point out that the figures refer to rats caught alive, and not to those found dead.

With the exception of Farm C, Nacton and the Labour Colony, no unusual mortality amongst rats had been lately observed, but on some of the estates the keepers volunteered the information that two and three years ago the rats had died in great numbers.

The situations visited were chosen more or less at random and can be located on the enclosed map by means of the numbers corresponding to each series of observations. During the first week we found plague-infected rats amongst those caught at six out of seven of the localities visited, whereas in the second week none were discovered. This may quite well have been due to a mere chance distribution, but the precise source of the rats was not identical. At first we obtained them mostly from hedge rows, later almost entirely from ricks. The possible significance of this will be discussed later.

The proportion of rats infected at Farm A, Culpho, Farm C, Nacton, and the Labour Colony in Woodbridge Union, viz., 4 out of 39, 5 out of 48, and 5 out of 35, respectively, was surprisingly large considering that these were caught rats and not those found dead.

At the height of the epizootic in Bombay the proportion found infected amongst live rats only once touched 6 per cent., whereas in these three places taken together the proportion amounts to 11 per cent. Although the actual number examined was small, it would appear that a severe epizootic was in existence there at the time.

At the Labour Colony we obtained evidence of a considerable mortality amongst rats which had taken place two to four weeks previously. The keeper stated that he had found between 200 and 300 dead rats upon the estate at this time, and that from a particular bank adjoining the marshes he had picked up 49. From this same bank we dug out a burrow containing 12 dead rats. Ten of these were too putrid for certain diagnosis, but two which had died more recently proved to be plague-infected.

This same bank was thoroughly ferretted on our second visit to the Labour Colony on December 28th, but was completely deserted.

PLAGUE AMONGST RABBITS.

We examined 40 rabbits. The majority of them were caught at the Labour Colony. Nine of them were examined in November and 31 in December. The rabbits were obtained by ferretting.

Two of the rabbits had plague, two were suffering from coccidiosis, and one from rabbit septicæmia (*pasteurellose du lapin*). The co-existence of this latter disease indicates the need for care in the diagnosis of plague amongst these rodents, as in the organs the cocco-bacilli of rabbit septicæmia may be microscopically indistinguishable from *Bacillus pestis*.

For this reason, and also because we are much less familiar with the manifestations of natural plague in rabbits than in

rats, the rabbits were subjected to a more detailed post-mortem examination, and the organisms obtained from them were submitted to a complete bacteriological examination.

The first rabbit which was proved to be plague-infected was either suffering from the disease in a chronic form or, more probably, recovering from an acute attack. The only lesion, post-mortem, was a greatly enlarged spleen full of nodules, not unlike those often seen in the spleen of a guinea-pig with the less acute form of pseudo-tuberculosis rodentium. The nodules contained some bipolar organisms and a number of involution forms, which were deemed at the time likely to be *Bacillus pestis*. There were no enlarged glands. No organisms were to be found in the blood or other organs.

Cultures of heart blood proved sterile, but, from the spleen, a pure culture, agreeing in appearance and mode of growth with *B. pestis*, was obtained. Microscopical preparations of this culture were similar to those of *B. pestis*.

Subcultures were made, and their fermentative and other characteristics were identical with those of the plague bacillus. Cultures were inoculated into rabbits, guinea-pigs, and rats. These animals all died, presenting pathological pictures characteristic of plague, and from their organs pure cultures of *B. pestis* were obtained.

The second rabbit was suffering from acute plague. It had a typical sub-maxillary bubo, and injection of the small vessels was especially marked in skin. The spleen was much enlarged, tense, and of a purplish colour. The peritoneum and pleuræ contained blood-stained fluid. The left lung was congested but not consolidated. The intestines were matted together by recent lymph.

Microscopical examination of the bubo, spleen, and liver showed numerous plague-like bacilli. Organisms with the cultural and fermentative characteristics of *B. pestis* were obtained from the bubo, spleen and liver. The heart blood proved sterile. Subcultures inoculated into rats produced typical pest.

The pathological findings in the rabbit, infected with rabbit septicæmia, are worth detailing, as they present certain resemblances to plague, especially as regards the microscopical appearances of the organisms. The right superficial inguinal gland was red and swollen, and the vessels in the neighbourhood congested. The skin generally was injected, and both skin and peritoneal lining had a pink flush. The spleen was enlarged and tense, and the liver mottled. So far the appearances might quite well have been that of an early case of acute plague. On opening the chest the pleuræ and pericardium were found to be full of fibrinous exudation, the heart being adherent to the parietal pericardium, and the lungs adherent to the pleuræ. There was double pneumonia, the whole of both lungs being semi-consolidated. On microscopical examination the pleural exudate, lungs, spleen, and the enlarged gland all showed bipolar staining cocco-bacilli together with diplococcal forms. Neither were stained by Gram's method.

Agar cultures were obtained from the pleural exudate and heart blood. The colonies were well developed after 18 hours incubation, and resembled those of rabbit septicæmia. In culture the

organism assumed the coccoid form exclusively. The fermentative characteristics of the organism coincided with that of rabbit septicæmia, and differed from plague in fermenting cane-sugar and forming indol. The organism was extremely pathogenic to rabbits, 1 cc. of a broth culture killing two large rabbits in less than 18 hours. At the autopsy the blood and organs contained bipolar-staining bacilli in enormous numbers. On the other hand, rats and guinea pigs inoculated with a similar quantity were unaffected.

We also examined five hares, two ferrets, one turkey cock, one fowl, and one dog, which had died under suspicious circumstances in neighbourhoods where the rats were found to be infected with plague. All these animals, however, proved not to have died from this disease.

OBSERVATIONS UPON THE HABITS OF THE BROWN RAT, *Mus decumanus*.

Mus decumanus is essentially a wild animal, but frequents usually the haunts of man for food supplies, particularly during the winter months. It can run, climb, and burrow. It is handy in the water, and can swim either on the surface or for long periods, upwards of two minutes, underneath. It is omnivorous, and can thrive on any sort of food stuff. Its powers of multiplication are enormous, and it is estimated that one female might under favourable conditions be responsible for more than 1,000 descendants within twelve months. In addition, it is possessed of courage, astuteness, and industry. These qualities, combined with the highly developed maternal instinct of the females, render it a very efficient animal.

Such a versatile creature can adjust itself to the exigencies of most situations. The following observations, however, refer to its habits in the country districts in East Anglia. In November we found the rats spread over the whole country, living either in burrows in the hedgerows, or in corn stacks. The largest number of burrows were in hedgerows adjacent to corn stacks, or near situations where potatoes were buried for the winter. In fact, the position in which the rat excavates its home is determined by the available food supply. It likes to be within convenient distance of supplies, but does not, as a rule, live in immediate proximity to them. The choice of position is apparently determined by two factors—nearness to food supply, and remoteness from the interference of man. The positions chosen were sometimes a little difficult to explain. Thus, in one instance observed by us, several large colonies of rats had excavated elaborate systems of passages and chambers on a bank thrown up to keep out the sea from some low-lying ground adjoining the estuary of the Alde, near the Labour Colony. No farm-house was nearer than about half a mile, and no source of food was obvious. On digging out the system the explanation was clear. The burrow contained a large quantity of the shells of mussels and whelks. This accumulation of emptied shells indicated the reason for the choice of the situation.

From this colony clearly defined tracks led inland for considerable distances in the direction of the farm. In the course of these tracks two broad dykes intervened, the track stopping at the edge of one bank and commencing again, immediately opposite, on the other. The intervention of some 10-20 ft. of water was evidently no impediment to the regular use of the track.

Mus decumanus generally makes its own holes and burrows, but occasionally it will utilise the hole of a rabbit.⁽¹⁾ The holes are, for the most part, made in the banks of hedges, and the external opening is so disposed that it is on the side of the bank some distance from the ditch below—a disposition which precludes the possibility of the entrance of water. In the summer-time, when, as we shall point out, the rats distribute themselves over the country side, the holes may be made directly downwards in the middle of a cornfield, but the disposition is usually as stated. From the opening a passage leads inwards into the bank, and ramifying about, opens at intervals upon the surface. The system of passages and chambers may, in the case of a colony of rats, be very complicated, with several openings on both sides of the bank. Here and there the burrow opens into a chamber used as a nest. The nest consists of dry grass or straw, and is kept beautifully clean and dry. Rats make additional burrows in the neighbourhood of their haunts into which they run for shelter when surprised, and others which they use as larders to store up food supplies for the winter. In such larders we found potatoes, acorns and carrots.

In the nest live the fleas, in conditions admirably adapted to their constitutions and wants, with abundance of food and a warm atmosphere. The fleas deposit their eggs in the rats' nests. Here also are to be found the larvæ and pupæ. If, at the time a rat leaves its nest, some fleas happen to be feeding on it, they perforce accompany it on its wanderings. Only a small proportion of the total number of fleas that feed on one rat will, therefore, be found upon it at any one time.

Regarding the question of the seasonal movements of rats, we were informed by rat-catchers and keepers that in the winter the rats are, in most cases, obliged to come into the neighbourhood of farm buildings for the reasons stated above, but that in the early summer, when the fields are full of grain and other ripening seeds, and when every hedgerow is alive with life of all sorts, the rat population distributes itself over the country. They then take up their quarters in the hedgerows, particularly those bordering arable land; in fact, wherever they can find food. Our own observations, though scanty, support these statements.

In many instances we searched, in December, holes in the banks which had recently been inhabited by rats, and found them forsaken. In November we encountered a recently inhabited extensive system of holes and runs in a stubble field, and thoroughly ferretted it, but found it deserted. When the corn was standing

⁽¹⁾ This, together with the fact that the common rat flea will, we find, feed on rabbits, may explain the spread of the disease to these animals. We found this flea on rabbits on two occasions at the Labour Colony.

there must have existed here a large colony of rats. When the corn was reaped, and all ears had been gleaned, the rats had evidently deserted it.

COMPARISON OF CONDITIONS EXISTING IN EAST SUFFOLK WITH
THOSE OBTAINING IN INDIA, FROM THE POINT OF VIEW OF THEIR
EPIDEMIOLOGICAL IMPORTANCE.

The conclusion to be drawn from recent investigations into the epidemiology of *bubonic*⁽¹⁾ plague, and particularly from the work of the Commission for Investigation of Plague in India, may be briefly summarised as follows:—

- (1.) In the great majority of cases, during an epidemic of plague, man contracts the disease from plague-infected rats through the agency of plague-infected rat fleas.
- (2.) The chance of human infection is determined by the number of hungry infected rat fleas, provided they will feed on man, and his accessibility for them.

As far as this country is concerned, the first essential in this chain of causation is satisfied. Rat-plague exists in East Anglia, and we have ascertained that rats, which have there succumbed to acute plague, present a degree of septicæmia comparable to that observed in India. Further, about half of the fleas on the rats belong to a species, *Ceratophyllus fasciatus*, which readily bites man, and some of these fleas taken off infected rats contained plague bacilli in their stomachs in considerable number. There is no reason to suppose that should such infected fleas feed upon man the chances of their transmitting the infection would be less than in the case of *Xenopsylla cheopis* in Bombay. Nevertheless, although there is reason to believe that rat plague has existed in East Suffolk for the last two or three years, the cases of transmission to human beings have been but few.

It is not difficult to explain the infrequency of transmission even in the presence, in certain localities, of an epizootic of such severity as would, in India, assuredly have been associated with the spread of the disease to man.

How far this relative immunity of mankind has depended upon the smaller number of fleas per rat in Suffolk compared with India we are not in a position to state. We do know, however, that only a proportion of the fleas here belong to a species which feeds on man, and it is quite likely that the effective flea prevalence upon rats has never reached the numbers usual in India during the plague season. As, however, we have not investigated this question during the late summer, a time when the flea population in temperate climates is at its maximum, we can only conjecture that such is the case.

⁽¹⁾ These conclusions refer to *bubonic* plague as encountered in recent times. It is possible that in the case of former epidemics the human flea may have played an active part and transmitted the disease from man to man directly. Observations made on the degree of septicæmia in human cases in India indicate that the number of bacilli in the circulation is rarely sufficient to admit of this agency being effective.

With regard to the accessibility of man for rat fleas (which, owing to the death of a large number of rats, are seeking a host) the greatest difference exists in the two countries.

The common rat of India is *Mus rattus*, *Mus decumanus* only occurring in three or four of the large seaport towns. Compared to his congener the brown rat, *Mus rattus* is a domesticated creature. Bred for numberless generations amidst a population which is averse to the destruction of animal life, and indifferent to the inconvenience of its presence, this rat lives in the closest association with man all over India. Even when the people occupy well constructed rat-proof buildings, families of rats may be found in the same room with mankind. A plentiful supply of food is provided for them both inside and outside the buildings. Grain and other eatables are stored inside the living rooms, the refuse is thrown into the streets just outside, and the remains of food supplied to animals (themselves kept in the living rooms or tethered near by) support a large rat population in closest proximity to the human inhabitants.

It was not uncommon to find rats' nests with a family of young ones amongst the belongings which are accumulated in their homes by the poorer classes. As pointed out above, the majority of the fleas are to be found in the rats' nests, so that the presence of nests in proximity to man is of much greater importance than the occasional clandestine visit of a rat to the premises.

The European, on the other hand, does not suffer the companionship of rats gladly. He will not, as a rule, permit them to live undisturbed and bring up a family in his bedroom. In this country *Mus decumanus* has therefore to make his home outside, and in the country to provide himself with a burrow in some spot as free as possible from molestation. In the summer, which is also the time when epizootic plague will be most prevalent and fleas most abundant, he betakes himself to some hedgerow as far away from habitations as circumstances permit.

Further differences in the domestic economy of the two peoples are not without influence. The Indian peasant's hut or room, as well as being bedroom, also serves to store his food supplies, whereas in this country, except amongst very poor people, food is not stored in the sleeping apartment. The Indian hut, with its floors of cow dung and its indescribable muddle and litter, in addition to providing cover for rats to nest, affords good breeding ground for fleas of all sorts. The amount of vermin infestation in these homes may be gathered from the fact that in one room in which dead rats had been found and plague cases had occurred the Commission for the Investigation of Plague in India secured 263 rat fleas.⁽¹⁾

Lastly, a large proportion of the population in India have bare feet and legs and sleep upon the floor, thus rendering them more accessible to the attacks of fleas.

(¹) Report, *loc. cit.* (1907), p. 784.

III.

Report upon the Examination of Rats, collected in Suffolk and Essex, for Plague Infection. January 16th to February 14th, 1911. By George Ford Petrie, M.D., Assistant Bacteriologist, Lister Institute, Member of the Commission for Plague Investigation in India, and George Hugh Macalister, M.A., M.D., Assistant Bacteriologist, Lister Institute.

In accordance with instructions received from the Local Government Board, we proceeded to Ipswich on January 14th, 1911. The examination of the rats took place in the laboratory of the medical officer of health, which had been kindly placed at the disposal of the investigation by the public health authority of the borough.

METHODS OF INVESTIGATION.

The rats were sent to the laboratory, bearing labels which gave the following particulars as to their source and method of capture:—

Date	Catcher
Address where found	
Whether outbuilding, stack or hedgerow	
More details as to exact place where the rat was found	
Found dead?	Ferreted? Shot? Trapped?
Has poison recently been laid down in the place?	
What kind of poison?	
Has virus recently been laid down in the place?	

After each rat was nailed out on a dissecting board, it was given a serial number; and the information supplied by the labels, and certain particulars obtained during the post-mortem examination, transferred to the card below:—

Serial No.	Date	Catcher.
Address where found		
Place where found		
Method of capture		
Has poison or virus been recently used in the place?		
Species	Sex	
Pregnant	No. of fœtuses	
Result of examination.		

INSPECTION WITH THE NAKED EYE.

The rats were opened so as completely to expose the viscera and the principal lymphatic glands. A careful search was made for any appearances suggestive of plague. The chief signs, to

which attention was directed, were the presence of a primary bubo, pleural effusion, subcutaneous hæmorrhages or granular changes in the liver. This order represents the relative importance of these appearances, in the diagnosis of plague, according to the experience of the Commission for the Investigation of Plague in India. Less important are enlargement of lymphatic glands, with or without suppuration, subcutaneous congestion, granular spleen and patchy congestion of the lungs. Of all these conditions, the presence of a bubo is by far the most important, and was found by the Commission in 84 per cent. of plague-infected rats.

Any rat, which showed appearances in the least suggestive of plague, was transferred to another table for further examination. Rats, which manifested changes of pathological interest, other than those due to plague, were also set apart. The remaining animals were removed from the dissecting boards, and transferred to a receptacle, pending removal to the destructor.

FURTHER STUDY OF SUSPICIOUS RATS.

Suspicious rats were submitted to a further scrutiny with the naked eye, and the post-mortem appearances were recorded on the card below:—

Post-mortem appearances.

Serial No.	Date of examination of rat
Putrid; emaciated; rigor mortis	Kidneys
Subcutaneous congestion	Lungs
Liver	Pleural effusion
Spleen	Pericardial effusion
Intestines	Hæmorrhages

Histological appearances.

Bubo	Spleen
Liver	Heart-blood

Results of Plate Cultures.

Bubo	Spleen
Liver	Heart-blood

By means of a platinum spud, portions of organs or glands which gave signs of morbid change were taken, and smears made upon slides. These were stained with carbol-thionin-blue, and examined microscopically for bacteria. At the same time cultivations were taken from one or more of the organs, heart-blood or lymphatic glands. These cultures were usually made on plates of MacConkey's lactose or mannite neutral-red-bile-salt agar. A few cultures were also made upon ordinary nutrient agar slopes. These were incubated at 30° C. for one, two or three days. The plates were then examined for colonies resembling those of *B. pestis*. The typical colony is red upon mannite plates, colourless upon lactose. It possesses no halo but an irregularly crenated edge. It is coherent, and moves

en bloc when touched with a platinum needle. The examination of these plates rendered it possible to eliminate a number from the list of suspicious rats.

Any suspicious colonies were sub-cultured on agar slopes, and further cultural tests applied. These were recorded as below upon a third card:—

Identification tests of Cultures isolated.

Serial No.	Date.	Source of culture
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Microscopical.—

Cultural.—

Glucose	Galactose
Mannite	Laevulose
Dulcite	Inulin
Saccharose	Isodulcite
Lactose	Glycerine
Maltose	Malachite green.
Adonite	

Virulence tests.—

Remarks.—

The fermentation tests caused a further reduction in the number of suspicious rats. Some of the organisms isolated showed fermentation with the production of acid and gas in certain sugar tubes, and were assigned to the group of intestinal organisms. Others gave sugar reactions different from those characteristic of plague. Organisms, whose fermentation reactions were not inconsistent with the *B. pestis*, were inoculated into rats and guinea-pigs with a view to their more complete identification.

SUMMARY OF THE RESULTS OF THE EXAMINATION.

6,071 rats were examined. Of these, all belonged to the species *Mus decumanus*. 3,273 were males, 2,724 were females, and in the remaining 74 the sex was not noted. 290, or 10·6 per cent. of the females were pregnant, the average number of foetuses being nine.

In no single rat were the post-mortem appearances typical of plague. No case presented a characteristic bubo.

Seventy-three rats, which showed signs of some kind of infection, were, however, set aside for further investigation. In many of these there was no adequate reason to suspect that the rats had suffered from plague, but they presented features of sufficient interest to warrant a more detailed scrutiny. Among them were four cases of rat leprosy, in which the causal organism was obtained from the local lesions. This class also included nine rats which showed signs of septic infection of the lungs. In early stages, the lungs were found on incision to contain one or more small cavities, full of glairy, semi-purulent material. In advanced stages, the normal lung tissue was replaced almost

entirely by a system of large cavities full of thick, caseous pus. The disease presented no similarity to plague, and the organisms isolated from these cases differed culturally and morphologically from *B. pestis*. A further study of these forms is now proceeding.

In the consideration of the remaining 60 rats, the possibility of plague infection was entertained, or the rats were reserved for other reasons. Fifteen of these showed marked congestion, suppuration, or necrosis in certain lymphatic glands, particularly those of the submaxillary region. In 45 cases there were granular changes in the liver and spleen. Twenty-two rats showed this condition in both organs, 17 in the spleen alone, and six in the liver alone.

Pieces of the organs, which gave evidence of pathological change, were spread upon mannite and lactose plates. In 21 cases no growth appeared upon these plates after three day's incubation at 30° C. Four cases gave growth of staphylococci and streptococci.

From 14 rats, cultures were obtained which showed soft red colonies upon both lactose and mannite plates. As the result of a further study of their morphological characters and fermentation reactions, they were identified with *B. coli communis*. In eleven cases, organisms belonging to the Gaertner group were isolated. These cases had presented marked granular changes in liver and spleen. Seven rats gave cultures of organisms which possessed no resemblance to *B. pestis*, but have not yet been identified.

In consequence of these successive eliminations, the number of rats regarded as suspicious was reduced to three. From these were obtained growths of bacilli very closely resembling *B. pestis*. The serial numbers of these rats were 113, 1,758, and 1,893. Short particulars are given below, and a full account of their investigation is to be found in the Appendix.

Rat No. 113. Post-mortem examination showed some congestion of the pelvic lymphatic glands, a pale, finely granular liver and granular spleen. There was also patchy congestion of the lungs. Microscopically examined, smears from various organs failed to show bacilli. On MacConkey plates, coherent plague-like colonies were obtained. The bacilli were small, coccil forms predominating. A few "giant" forms were found. The bipolar staining was not marked. On agar, the culture resembled plague, but growth was more rapid than is usually the case with plague. This greater rapidity of growth was also seen in sugar media, and caused fermentation-reactions to be manifested sooner than with *B. pestis*. Cultivations in broth showed a flaky deposit with a few abortive stalactities hanging in the clear fluid. Guinea-pigs were readily killed by subcutaneous inoculation. It was only feebly virulent to rats. Fifteen rats were inoculated with large doses, such as half an agar slope or 2 c.c. of broth culture; only three of these died, one three days after subcutaneous inoculation, another four days after receiving a large injection intraperitoneally. In the rats which recovered a local swelling appeared which was absorbed in some cases, while

in others it proceeded to the formation of an abscess, which subsequently burst.

No. 1,758. Post-mortem, a finely granular spleen was the only abnormality noted. Cultivations from this gave growth of plague-like colonies. Microscopically these were found to consist of non-motile cocco-bacilli, but a few long, involution forms were seen. Culturally and in its fermentation reactions it resembled the foregoing. It was pathogenic to guinea-pigs, but only possessed feeble virulence against rats. Of six rats inoculated, one which had received a large dose of a broth culture intraperitoneally, died. The other rats survived, showing swelling and abscess-formation as in the case of No. 113.

Rat No. 1,893 presented, at the post-mortem, a granular spleen and a liver sparsely marked with fine granulations. In the main, the cultural and morphological characters of the organism isolated resembled those of Nos. 113 and 1,758. Broth cultures were somewhat more turbid than the foregoing, but the same tendency to abortive stalactite formation was observed. Guinea-pigs proved to be susceptible to subcutaneous inoculation, but rats appeared quite highly resistant.

These three cultures were very closely akin to *B. pestis*, and thus their correct allocation is important. Certain morphological characters, the occurrence of involution forms, fermentation reactions, and their capacity for growth upon bile-salt media precluded their assignment to the Pasteurella group proper. On the other hand, *B. pseudo-tuberculosis rodentium* will grow under the same conditions as *B. pestis*: it produces fermentation reaction differing in degree rather than quality from those due to *B. pestis*. It has generally been held to possess little or no virulence for rats, whereas guinea-pigs succumb readily to small doses. The problem to be solved in connection with the three cultures under investigation was whether they should be regarded as pseudo-tubercle, occurring naturally amongst wild rats, or as plague, which was practically avirulent for these animals.

Klein⁽¹⁾ held that these two types of organism could be distinguished by means of their cultural and morphological characters as well as by the nature of the pathological lesions consequent upon inoculation of experimental animals. Galli-Valerio,⁽²⁾ while admitting that they resembled one another in their main features, considered that certain details of cultural appearances afforded data for precise diagnosis. There is no doubt, a distinction between a typical plague culture and a typical pseudo-tubercle culture, but investigators, who, making use of a relatively greater number of strains, have had the opportunity of studying atypical cultures, are not inclined to make light of the difficulties of diagnosis. Zlatogoroff⁽³⁾ arrived at the conclusion that, culturally and morphologically, the two organisms are practically indistinguishable. He attempted unsuccessfully to produce cross-immunisation, and concluded that diagnosis could be effected by this means. MacConkey,⁽⁴⁾ however, was successful in his cross-immunisation experiments, and found, moreover, that, in cultures grown upon

agar, gelatine, or in broth, no constant differences in the appearances of the growth or of the bacilli could be determined.

The diagnosis of various organisms by means of their different fermentation reactions has of late years been very extensively practised. It appeared at first that the application of this method might be of use in the present case. Dr. Mervyn Gordon, who is largely responsible for the development of this means of diagnosis, was kind enough to give us the information that whereas the pseudo-tubercle readily ferments iso-dulcite and glycerine, with the production of acid, the plague bacillus did not produce this change. MacConkey pointed out that pseudo-tubercle after a few days produced an alkaline reaction in litmus milk, while *B. pestis* caused no perceptible change. We have also observed that malachite-green broth is either not, or with extreme slowness decolourised by the plague bacillus, but that tubes inoculated with *B. pseudo-tuberculosis rodentium* lose the colour in two or three days. While most of the strains of *B. pestis* with which we have worked may be differentiated from pseudo-tubercle by means of their incapacity to ferment isodulcite and glycerine, and their failure to decolourise malachite green, certain strains, including one obtained from Bombay and one isolated from a rat in East Suffolk last year, do ferment either isodulcite or glycerine, and may decolourise malachite-green. In every case, however, the action of *B. pestis* was much less energetic than that of *B. pseudo-tuberculosis rodentium*.

As to the value of diagnostic methods depending upon the binding of complement, there is some difference of opinion. Our colleague, Dr. Henderson-Smith, has carried out experiments which demonstrate that cross deviation occurs. On the other hand, Damperoff⁽⁵⁾ and Vay⁽⁶⁾ have recently done some work by which they claim to have shown that the organisms can be distinguished by this means.

This evidence shows that the correct identification of the three cultures afforded a problem of no inconsiderable difficulty. They presented appearances upon plates of agar or of MacConkey's media not inconsistent with those of either type. In broth they produced abortive stalactites, such as occur in cultures of certain strains of pseudo-tubercle, but differing from those seen in a typical plague culture. Growth took place upon all media with greater rapidity than in the case of plague cultures placed in parallel conditions, in spite of the fact that these latter had been kept upon artificial culture media for considerably longer periods. Further investigations upon the possibility of immunising against plague by means of these organisms, and upon serum reactions, are in progress, but pending the completion of these experiments, a statement of the position may be made.

Three rats out of 6,071 were found to be suffering from an infection due either to pseudo-tuberculosis rodentium naturally occurring amongst them, or to a form of pest virulent for guinea-pigs but not for rats, and the virulence of which for rats we have not so far succeeded in raising by "passage" through

guinea-pigs. We consider this fact of importance. Cultures of plague grown for numerous generations lose to a certain extent their virulence for rats, whilst still capable of infecting guinea-pigs. When, however, these strains are recovered from the bodies of guinea-pigs so infected, they are usually found to have regained their virulence for rats.

We are inclined to regard these cultures as pseudo-tubercle, firstly, on account of the general fermentation characters—these appear in tabular form in the Appendix—and secondly, on account of the pathogenicity, which more closely resembles that of pseudo-tubercle. These cultures present features of considerable interest, and the results of further work upon them will be reported in due course.

In conclusion, we must express our deep indebtedness to Dr. A. M. Pringle, medical officer of health for the borough of Ipswich, through whose kind offices the municipal laboratory was made available for the investigation, as well as for rendering ready assistance in various ways, during the course of the enquiry. To Mr. C. J. Huddart also, who accepted sole responsibility for the clerical work involved in the compilation of the card index, for this and for ungrudging co-operation in other ways, our most cordial thanks are due.

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 - (5) Damperoff. Centralb. f. Bakt. Abt. I., Orig. Bd. LV., pp. 188-192.
 - (6) Vay. Tom. cit., pp. 384-402.
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APPENDIX.

Cultures from rats 113, 1,758 and 1,893.

Rat No. 113. On mannite MacConkey plates, a pure growth was obtained of red colonies, with no marginal halo, but having a somewhat crenated border. By means of a platinum needle, the colonies could be moved *en bloc* over the surface of the medium. A film preparation showed that these colonies consisted of cocco-bacilli, together with some giant involution forms. Bipolar staining was not marked. They were Gram-negative and non-motile. Subcultures upon agar presented appearances typical of *B. pestis*. Broth cultures showed a clear fluid, with flaky sediment; another point of resemblance to *B. pestis*. Flasks containing 200 c.c. of

broth were inoculated in order to demonstrate stalactite formation. Only abortive stalactites were produced, whereas broth flasks inoculated with plague cultures and kept under exactly the same conditions showed good stalactites. Table II., given below, shows a comparison between the fermentation reactions of this organism and those of plague and pseudo-tubercle. It is to be noted the main differences consist in the rate at which fermentation changes take place. An interesting point observed was that whereas this organism freshly isolated produced no change in malachite-green broth, later subcultures decolourised it in four days. Particulars of inoculation experiments are given in Table I.

This organism resembles plague in its microscopical characters, and in the appearance of its growth upon agar. It differs from it in the rate of growth upon agar and the time taken to effect certain fermentation reactions. The stalactites formed are not like those of plague, but resemble those sometimes obtained with pseudo-tubercle cultures. The inoculation tests distinguish it from typical plague on account of its feeble virulence to rats. The only point against its identification with *B. pseudo tuberculosis* is the natural incidence of infection amongst rats, but the data available are not sufficient to make this a point of critical value in diagnosis. This organism is therefore considered to be identical with the pseudo-tubercle bacillus.

Rats No. 1,758 and 1,893 yielded cultivations of small coccus bacilli which resembled the foregoing in their main features. They were non-motile, and some long forms were present. The fermentation reactions were similar, as is shown in table II. No. 1,758 formed abortive stalactites in broth; No. 1,893 gave a turbid growth. Inoculations show that these organisms are only in the smallest degree virulent to rats, while guinea-pigs succumb readily.

These three cultures all present in the main the same features; and the results of these cultural and inoculation experiments indicate that they conform to the type *B. pseudo-tuberculosis rodentium*. All three rats came from a certain limited area in the north-east corner of Essex.

TABLE I.

Culture.	Animal.	Date of Inoculation.	Method and Dose.	Results, Symptoms and Fate.	Pathological Appearances. Cultivations.
Original strain ...	Rat I.	25.1.11	Half agar slope subcutaneously.	Local swelling which subsided. Survived. Killed, 20.2.11.	Slight matting of tissues locally. Slight pitting of liver and spleen. Smears and cultures from organs showed no bacilli.
" " ...	Guinea-pig I.	4.2.11	" "	Ill, 6.2.11. Died, 9.2.11.	Locally dry caseous matter under skin and in thigh muscle. Skin somewhat injected. Left pelvic gland caseous. No periglandular congestion. Spleen very large deep red with nodules. Liver full of fine pin-point tubercles. Lungs show some congestion. Smears from glands and organs show scattered groups of plague-like bacilli, many of them in leucocytes. Cultures from liver and gland gave pure growths of typical plague-like cultures. Microscopically typical ovoid bacilli with involution forms.
" " ...	Rat II.	4.2.11	" "	Abscess in thigh which burst, 10.2.11. Healed, 14.2.11. Killed, 20.2.11.	Cultures from pus gave pure growth of small cocco-bacillus with no involution forms.
Culture from Guinea-pig I.	" III.	12.2.11	" "	Local swelling which disappeared after five days. Killed, 20.2.11.	Enlarged left inguinal and pelvic glands. Smears showed a few cocci and cocco-bacilli. No growth was obtained on cultivation.
Original strain ...	Guinea-pig II.	17.2.11	One-third agar slope subcutaneously.	Ill, 20.2.11. Died, 23.2.11.	Nothing abnormal. Smears and cultures negative.
					Locally matting and necrotic changes. Congested right inguinal gland. Enlarged pelvic gland in right side with surrounding oedema. Granular liver and spleen. Some pleural and peritoneal effusion; patchy congestion of lungs. Smears showed cocco-bacilli. Smears from peritoneal fluid showed active phagocytosis. Cultures gave pure growth of same organism which was tested with fermentation reactions.

TABLE II.—SUGAR REACTIONS.

Cultures.	Glucose.	Mannite.	Dulcite.	Saccha-rose.	Lactose.	Maltose.	Adonite.	Galactose.	Laevulose.	Inulin.	Iso-dul-cite.	Glycerine.	Malachite Green.	Litmus Milk.
113. Original Ipswich	A. 1	A. 1	—	—	—	...	—	—	A. 1	—	A. 2	A. 7	—	Alk. 8-10.
113. After subculture	A. 1	A. 1	—	—	—	A. 2	—	A. 3	A. 1	—	A. 3	A. 4	+ 2	Alk. 8-10.
113. After passage through guinea-pig	A. 1	A. 1	—	—	—	A. 1	—	A. 4	A. 1	—	A. 2	—	+ 3	Alk. 8-10.
1758. Ipswich	A. 1	A. 1	—	—	—	A. 1	—	A. 5	A. 1	—	A. 1	...	+ 3	Alk. 8-10.
1893. Ipswich	A. 1	A. 1	—	—	—	A. 2	—	A. 3	A. 1	—	A. 2	A. 3	+ 4	Alk. 8-10.
B. pestis. Bombay, 1898	A. 1	...	...	...	...	—	—	A. 3	...	...	—	A. 7	—	—
" Glasgow, 1903	A. 1	...	...	...	...	—	...	—	...	...	A. 8	—	—	—
" Kolle I.	A. 1	...	...	...	...	A. 4	...	A. 5	...	...	A. 9	—	—	—
" Elstree	A. 1	...	...	...	...	A. 3	...	—	...	...	A. 10	—	—	—
" Kolle II.	A. 1	...	...	...	...	A. 2	...	A. 5	...	...	A. 6	—	—	—
" Suffolk Rabbit. 1910(150A)*	A. 1	...	...	...	...	A. 5	...	A. 9	...	...	—	—	±	—
" Suffolk Rat. 1910 (143M) ^o	A. 1	...	...	...	...	A. 4	...	A. 6	...	...	A. 9	—	—	—
" Suffolk Rat. 1910 (166) ^o	A. 1	...	...	...	...	A. 4	...	A. 7	...	...	A. 9	—	—	—
B. pseudo tuber. Rodent I.†	A. 1	A. 1	...	...	...	A. 1	...	A. 3	...	...	A. 1	A. 8	+ 3	Alk. 8-10.
" II.†	A. 1	...	...	...	...	A. 1	...	A. 2	...	...	A. 1	A. 6	+ 3	Alk. 8-10.
" III.†	A. 1	A. 1	...	...	...	...	...	...	...	...	A. 2	A. 4	...	Alk. 8-10.
" IV.†	A. 1	A. 1	—	—	—	...	—	...	...	—	A. 2	A. 8	...	Alk. 8-10.
" V.†	A. 1	A. 1	—	—	—	...	—	...	...	—	A. 2	A. 5	...	Alk. 8-10.
" VI.†	A. 1	A. 1	—	—	—	...	—	...	...	—	A. 2	A. 5	...	Alk. 8-10.
" VII.†	A. 1	A. 1	—	—	—	...	—	...	...	—	A. 2	A. 5	...	Alk. 8-10.
" VIII.†	A. 1	A. 1	—	—	—	...	—	...	...	—	A. 2	A. 5	...	Alk. 8-10.
" IX.†	A. 1	A. 1	—	—	—	...	—	...	...	—	A. 2	A. 4	...	Alk. 8-10.
" X.†	A. 1	A. 1	—	—	—	...	—	...	...	—	A. 2	A. 4	...	Alk. 8-10.
" XI.†	A. 1	A. 1	—	—	—	...	—	...	...	—	A. 2	A. 4	...	Alk. 8-10.

A = Acid. The number indicates the number of days which elapse before the reaction appears. + = Decolourised.

* Strains isolated in East Suffolk in November and December 1910, during investigation by Drs. Martin and Rowland.

† Lister Institute strains. ‡ Pasteur Institute strains. § blstree strains.

The investigation of sugar reactions of the pseudo-tubercle cultures III. to XI. was kindly undertaken by Dr. MacConkey, who compared them with those of our Ipswich cultures.

TABLE III.

Culture.	Animal.	Date of Inoculation.	Method and Dose.	Results. Symptoms and Fate.	Pathological Appearances. Cultivations.
1758 Original ...	Rat I.	6.2.11	Half agar slope subcutaneously.	Local abscess, 13.2.11. Killed, 20.2.11.	Inguinal gland enlarged. Granular spleen. Smears and cultures negative.
" "	Guinea-pig I.	16.2.11	" "	Local swelling, 17.2.11. Dead, 22.2.11.	Necrosis and matting at site of inoculation. Smear showed a few deeply staining cocco-bacilli. Granular spleen; smear showed bipolar bacilli. Lungs congested; portions of lower lobe sink in water. Smears nil. Pelvic gland enlarged with surrounding oedema-nests of cocco bacilli. Heart-blood nil. Liver not markedly granular. Smears showed a few nests of cocco-bacilli.
" "	Rat II.	23.2.11	" "	Local swelling, 26.2.11. Killed, 4.3.11.	Nothing abnormal found.
" "	" III.	23.2.11	" "	Local swelling, 27.2.11. Killed, 4.3.11.	" "
" "	" IV.	23.2.11	Half agar slope intraperitoneally.	Dead, 27.2.11.	Peritoneal effusion. Much lymph. Microscopically large numbers of leucocytes crowded with bipolar bacilli. Liver and spleen faintly granular. Culture obtained pure from peritoneal fluid.
Culture from Rat IV. Peritoneal fluid.	" V.	3.3.11	One-third agar slope subcutaneously.	Killed, 17.3.11.	Nothing abnormal found.
1893 "Original ...	" VI.	3.3.11	" "	Killed, 17.3.11.	" "
" "	" VII.	6.2.11	Half agar slope subcutaneously.	Local swelling, 13.2.11. Killed, 20.2.11.	Left inguinal abscess. Smear showed phagocytosis of cocco-bacilli. Cultures obtained pure.
" "	Guinea-pig II.	16.2.11	" "	Local swelling, 17.2.11. Dead, 20.2.11.	Local matting of tissues and necrosis. Large granular spleen. Granular liver. Smears showed a few cocco-bacilli. Pelvic glands enlarged. Smears showed cocco-bacilli undergoing phagocytosis.
" "	Rat VIII.	23.2.11	" "	No symptoms. Killed, 3.3.11.	Granular liver. Nothing found in smears.
" "	" IX.	23.2.11	" "	Local swelling, 26.2.11. Killed, 3.3.11.	Faint granules in the liver.
" "	" X.	23.2.11	Half agar slope intraperitoneally.	Ill, 25.2.11. Recovered. Killed, 3.3.11.	Nothing abnormal found.

APPENDICES.

Letter. (1.)
Certain Sanitary Authorities.

PLAGUE—WEEKLY REPORTS.

Local Government Board,
 Whitehall, S.W.,
 21st November, 1910.

SIR,

I AM directed by the Local Government Board to advert to the occurrence of plague in animals in certain sanitary districts in the East of England, of which the is one.

The Board will be obliged if the District Council will instruct their Medical Officer of Health to furnish the Board, until further notice, with a weekly report, as regards his district, bringing information on the subject up to the date on which the report is made.

The report should state (1) the number of rats or other animals, if any, which have been examined during the week, and the number which have been found to be infected with disease; (2) the action taken for the extermination of rats, for the prompt removal of refuse from the vicinity of houses, for preventing the entrance of rats into buildings and other premises, and for the isolation of suspected human cases of illness, if any; and (3) any other information of value in connection with the subject.

I am, Sir,

Your obedient Servant,

F. J. WILLIS,

Assistant Secretary.

Circular. (2.)
Sanitary Authorities.

PREVENTION OF EPIDEMIC DISEASE.

REGULATIONS AS TO PLAGUE.

DESTRUCTION OF RATS.

Local Government Board,
 Whitehall, S.W.,
 10th November, 1910.

SIR,

I AM directed by the Local Government Board to state that, in consequence of the occurrence of cases of plague in rats in certain parts of England, they have deemed it desirable to confer upon local authorities in England and Wales powers with regard to the destruction of rats, in districts where plague in rats is present or suspected or in which there is an unusual mortality among rats.

The Board have accordingly, in pursuance of their powers for the prevention of epidemic diseases, issued an Order, copies of which are enclosed, authorising the local authority to take measures for the destruction of rats and for preventing their entrance into buildings and other premises.

The Board are glad to learn that in many localities active steps are being taken by owners and occupiers for the extermination of rats. They trust that these steps will not be abated, and

that all individuals will do their utmost to co-operate with and assist the local authorities in carrying out the Regulations.

The Order refers not only to the destruction of rats but to the prevention of their entrance into buildings and other premises. Inasmuch as the risk of infection from plague-stricken rats arises mainly through fleas it is obviously to the interest of all persons to do what they can to prevent their entry into dwellings and to remove from the proximity of dwellings accumulations of material or rubbish which may harbour them. In this way as well as by action by the local authority under the regulations, much may be done to further the object in view.

Copies of a memorandum on plague which has been prepared by the Board's medical officer will be forwarded in a day or two.

The Order and this circular will be placed on sale, so that copies may shortly be obtained either directly or through any bookseller from Messrs. Wyman & Sons, Limited, Fetter Lane, E.C.

I am, Sir,
Your obedient Servant,
H. C. MONRO,
Secretary.

The Clerk to the Port Sanitary Authority

or

The Town Clerk,

or

The Clerk to the Urban District Council

or

the Rural District Council.

(3.)

56,223.

(10th November, 1910.)

PREVENTION OF EPIDEMIC DISEASES.

REGULATIONS AS TO PLAGUE.

DESTRUCTION OF RATS.

To the Mayor, Aldermen, and Commons of the City of London;—

To the Councils of the several Metropolitan Boroughs;—

To the Councils of the several Municipal Boroughs and other Urban Districts;—

To the Councils of the several Rural Districts;—

To the several Port Sanitary Authorities;—

And to all others whom it may concern.

Whereas We, the Local Government Board, are empowered by the Public Health Act, 1875, as extended to London by the Public Health (London) Act, 1891, and as amended by the Public Health Act, 1896, from time to time to make, alter, and revoke such Regulations as to Us may seem fit, with a view to the treatment of persons affected with Cholera, or any other epidemic, endemic, or infectious disease, and preventing the spread of Cholera and such other diseases, as well on the seas, rivers, and

waters of the United Kingdom, and on the high seas within three miles of the coasts thereof, as on land, and for guarding against the spread of disease; and may provide for the enforcement and execution of such Regulations:

Now therefore, We, the Local Government Board, do, by this Our Order, and in the exercise of the powers conferred on Us by the Public Health Act, 1875, the Public Health (London) Act, 1891, and the Public Health Act, 1896, and every other power enabling Us in that behalf, make the following Regulations, and Declare that the said Regulations shall apply and have effect throughout England and Wales, and shall be enforced and executed by the Authorities, Officers, and Servants hereinafter mentioned:—

Article I.—In this Order—

The expression “Local Authority” means the Common Council of the City of London, the Council of each Metropolitan Borough, the Council of each Municipal Borough or other Urban District, the Council of each Rural District and each Port Sanitary Authority;

The expression “District” means the District of a Local Authority.

Article II.—In any district in which a representation is made to the Local Authority that rats in the district are infected or threatened with Plague, or that there is an unusual mortality among rats in the District, the Local Authority shall report the matter to Us, and shall take measures (a) for the destruction of all rats in the district and (b) for preventing the entrance of rats into buildings and other premises in the district.

Article III.—For the purposes of these Regulations the Local Authority may appoint such additional officers or servants as they may deem necessary and may delegate to such officers or servants any powers under these Regulations.

Article IV.—The expenses incurred by a Local Authority in the execution of these Regulations shall be defrayed in the case of a Local Authority which is a Sanitary Authority for the execution of the Public Health (London) Act, 1891, as part of their expenses in the execution of that Act, and in the case of any other Local Authority as part of their general expenses in the execution of the Public Health Acts.

Given under the Seal of Office of the Local Government Board, this Tenth day of November, in the year One thousand nine hundred and ten.

(L.S.)

JOHN BURNS,
President.

H. C. MONRO,
Secretary.

NOTICE.—The Public Health Act, 1896, provides by subsection (3) of Section 1 that if any person wilfully neglects or refuses to obey or carry out, or obstructs the execution of, any regulation made under section one hundred and thirty, or section one hundred and thirty-four of the Public Health Act, 1875, or

in pursuance of either of those sections as extended to London by the Public Health (London) Act, 1891, and as amended by the Public Health Act, 1896, he shall be liable to a penalty not exceeding one hundred pounds, and in the case of a continuing offence to a further penalty not exceeding fifty pounds for every day during which the offence continues.

(4.)

Circular.

*Sanitary Authorities in England and
Wales (including London).
Plague.*

Local Government Board,
Whitehall, S.W.,
12th November, 1910.

SIR,

I AM directed by the Local Government Board to advert to their circular letter of the 10th instant, and to forward to the sanitary authority the enclosed copies of a memorandum which has been prepared by the Board's medical officer on the subject of plague, together with directions for obtaining and forwarding for bacteriological examination material from suspected plague cases.

A copy of the memorandum and of the directions should be given to the medical officer of health, and a copy of the memorandum to the inspector of nuisances.

I am to request that the sanitary authority will instruct their officers to use their best endeavours to secure the carrying into effect of the suggestions which the memorandum contains.

The memorandum will be placed on sale, so that copies may shortly be obtained either directly or through any bookseller from Messrs. Wyman & Sons, Limited, Fetter Lane, E.C.

I am, Sir,

Your obedient Servant,

H. C. MONRO,
Secretary.

The Clerk to the Port Sanitary Authority

or

The Town Clerk,

or

The Clerk to the Urban District Council

or

the Rural District Council.

(5.)

MEMORANDUM ON PLAGUE.

I.—General Characteristics of the Disease.

After frequent recurrences during several centuries, ending with the great outbreak of Plague in 1664-1679, the disease disappeared from Great Britain for more than 200 years. In 1894

it became prevalent at Hong Kong, and since that time it has spread from Asia into various parts of Europe, America, Africa, and Australia. In 1900 and in two subsequent years small outbreaks have occurred at Glasgow, and one or more cases have also occurred at Liverpool, Cardiff, and Leith during the last ten years.

During the present year (1910), cases suspected to be pneumonic plague were associated in Suffolk with definite occurrence of plague in rats and other rodents.

In view of these facts sanitary authorities and their officers should be on the alert, and especially should they take steps for ascertaining the cause of any recognised excessive sickness in rats, or of human illness of a doubtful nature associated with sickness or mortality in rats in the same district.

The following facts with regard to plague should be borne in mind:—

(1.) *Symptoms of Plague.*

An attack of plague usually begins some three to five days after exposure to infection. The attack may develop gradually, but, commonly there is sudden onset with much fever, as indicated by a high temperature, rapid pulse, headache, hot skin, and thirst. The eyes are injected; the expression, at first anxious, becomes subsequently vacant and dull; the utterance is thick, and the gait unsteady as in one under the influence of drink. There is at times a distinct tendency to faint. The tongue is at first covered with a moist white fur except at the edges, which are red, but later on it becomes dry and of a mahogany colour.

The most distinctive sign of plague is the presence of glandular swellings, or "buboes" as they are called, in the groin, armpit, or neck. These "buboes," which led to the disease being called "bubonic plague," appear, as a rule, about the second or third day of the disease. They are usually painful and tender on pressure, and in size they vary from that of an almond to that of an orange. Later on they may "gather" and burst like an ordinary abscess. In a few cases "carbuncles" occur.

Cases of plague occur in which buboes are greatly delayed or even absent, as for instance in "Pneumonic," "Gastric," and "Septicæmic" plague.

In addition to the above-mentioned forms, plague sometimes takes on the so-called "ambulant" form. In plague of this description the affected person is hardly ill at all, presenting no definite symptoms perhaps beyond indolent, though painful, swellings in groin or armpit. Such plague cases may nevertheless be instrumental in spreading the disease, and any persons therefore who, having been possibly exposed to plague, exhibit these symptoms, should be isolated and watched medically until the nature of their malady has been definitely ascertained.

(2.) *Diagnosis of Plague.*

The three most important forms of plague—bubonic, septicæmic, and pneumonic—are very liable to be confused with venereal diseases, enteric or typhus fever, and ordinary pneumonia

respectively; and the differentiation will be greatly facilitated (a) if the medical practitioner bears the possibility of plague in mind, (b) if he enquires carefully into the antecedents of the patient, and into the occurrence of rat sickness or mortality, and (c) if he avails himself of the bacteriological aid to diagnosis mentioned below. The occurrence at or about the same time or in succession of more than one case of pneumonia in a house, or the unusual prevalence of disease of a dubious character in a neighbourhood, should at once lead to suspicion and to the action needed to clear up the diagnosis.

(3.) *Method of spread of Plague.*

The pneumonic form of plague is directly infectious from patient to patient, the expectoration and possibly also the droplets ejected when the patient coughs containing plague bacilli. The means for avoiding personal infection are set out below.

In bubonic plague there is a consensus of experience that personal infection rarely, if ever, occurs; and that, given elementary cleanliness, including absence of fleas and bugs, little risk is run by doctors or nurses or other attendants. Bubonic plague is the rule, pneumonic plague is rare. That infection from patient to patient seldom occurs is further shown by the comparative infrequency of multiple cases of plague in invaded houses. Experimental observations* have shown that the plague bacillus has only a short extra-corporeal vitality; and that infected soil and dust need not be considered as serious or continuing sources of infection.

It has also been shown that experimental feeding of animals with virulent plague material produces the disease only when the infective material is given in enormous doses. Apart from the protection afforded by cooking, such massive infection of human food is highly improbable. It is, however, desirable that the access of rats and mice to human food should be prevented.

In the majority of cases of human plague the virus enters through the skin by means of a flea-bite, occasionally by inoculation in other ways. Under experimental conditions the chance of infection varies with the number of infected fleas which are allowed to bite the subject of the observation. The risk of infection therefore may be regarded as likely to be proportional to the extent to which the house or workplace is infested by plague-infected fleas.

(4.) *Rats the source of Plague.*

Plague for administrative purposes may be regarded as a disease of rats which incidentally and occasionally attacks man. Fleas form the intermediaries between the diseased rat and man. If the fleas of infected rats (or the fleas of such other animals as occasionally suffer from plague) are excluded from access to human beings, plague will seldom, if ever, spread from animals to man.

* See Reports on Plague Investigations in India in Journal of Hygiene, particularly Vol. 8, No. 2 (1908).

The species of rat and the species of fleas infesting the rat have an important bearing on the likelihood of infection spreading to man.

During the great epidemic of plague in England in the 17th century, the black rat (*Mus rattus*) was chiefly prevalent. The brown or Norwegian rat (*Mus decumanus*) began to invade England early in the 18th century, and soon almost entirely replaced its smaller and weaker rival in this country. The change bears on the possibility of the occurrence of human plague in this country. The brown rat in towns is found chiefly in sewers, docks, slaughter-houses, granaries, &c. In the country it lives in burrows in the hedgerows and ditches and in ricks. It is a shy animal and avoids man, seldom taking up its abode in human habitations. In India the black rat lives and breeds in the houses and huts of the natives, in close proximity to man. Both the flea *ceratophyllus fasciatus*, which commonly infests rats in this country, and *pulex cheopis*, which is the usual rat flea in India and other tropical countries, readily feed upon man when hungry and when their natural host is not available; *pulex cheopis* is usually considered to bite man more readily than the former.

II.—Measures against Plague.

The chief measures requiring to be taken to prevent the spread of plague follow from the knowledge of its natural history which has been acquired in recent years, especially as the result of the work of the Indian Plague Commission.

Measures concerned with the prevention of importation of infection from abroad are regulated by the International Sanitary Convention of 1903, and need not be considered in this Memorandum.

The experience of Glasgow shows that in this country the disease in man can easily be controlled under conditions of efficient sanitary administration.

The measures to be taken in respect of plague occurring in this country concern (a) human sources of infection, (b) infection from inanimate objects, and (c) infection from lower animals, especially the rat.

(a.) Precautions against human infection.

The first step in the control of spread of infection from patient to patient is the discovery of suspected cases of illness and their prompt notification to the medical officer of health.

Notification.—The Board's Order of September, 1900, requires under penalty immediate notification to the medical officer of health of the district, and by him to the Board, of every recognised case of plague. To aid in this recognition the sketch of the clinical features of the malady given above has been inserted in this Memorandum. Further, in order to aid in identifying plague newly developing in a district, the Board have arranged for

Bacteriological Diagnosis, without cost to the local authority, of material sent to the Board's medical officer by the medical officer of health from the earliest suspected cases.

Isolation and Observation of "contacts."—Although it is only in the pneumonic form of disease that personal infection is likely to occur, the isolation of all patients suffering from plague is desirable, among other reasons, because disinfection and the disinfection of premises from vermin can be more efficiently secured after the patient's removal. It is important to keep under observation those who have been in contact with the patient or exposed to the same conditions.

The Production of Personal Immunity.—Those persons who are liable to be exposed to direct infection will do well also to protect themselves beforehand by means of the plague prophylactic, which had been found to be successful in India in protecting attendants and others exposed to infection under very dangerous conditions. Plague prophylactic should be obtained by the medical officers of health of districts actually invaded by plague, for the protection of doctors and nurses who may have to attend cases of plague, or others who may be exposed to infection. Any person attending a patient with recognised or suspected pneumonic plague should use strict precautions to avoid infection. Among such precautions may be mentioned personal cleanliness, especially of the hands, and the use of a respirator containing a film of cotton, made to cover the nose and mouth.

The part played by man in spreading bubonic plague is small. Hence measures taken against him have a correspondingly limited influence in preventing the propagation of plague. In the case of pneumonic plague direct personal infection occurs. Such outbreaks are successfully dealt with by isolation of the patients and observation of contacts.

(b.) *Precautions in regard to Inanimate Objects.*

These are concerned with the destruction of infective material derived from man or from animals, and with removing the harbourage for rats.

As already stated, the plague bacillus does not live long outside the animal body, even in excreta or in discharges from the lungs or abscesses. It is, however, important thoroughly to disinfect and cleanse infected dwellings. The disinfection and cleansing which will be most efficient will be such as will secure the disinfection of the rooms and of all articles of bedding and clothing from fleas. Clothing, which may harbour infected fleas, is dangerous. Fleas are to be found in dust and rubbish in dirty, untidy houses; hence the importance of domestic cleanliness in the prevention of plague.

The removal of all heaps of refuse, especially of garbage affording food for rats, the removal of empty boxes or any rubbish allowing rats to hide near houses, the stopping up of rat-runs with broken glass and tar, the repairing or re-laying of drains in houses where there are rat-runs, are among the most important methods for preventing the spread of plague by the rat. It is also important securely to stop up entrance to spaces under floors

of dwellings and outbuildings where rats may harbour.* These and other like measures, which will occur to all, are directed towards preventing the access of rats to or their entrance into houses. If rats are kept out of dwellings, danger is relatively small. There is difference of opinion as to the keeping of cats. Cats which have worried plague-infected vermin may bring rat-fleas into the house; but the presence of a cat in a house is one of the best safeguards against domestic invasion by rats or mice. The balance of evidence appears to be strongly in favour of the protective influence of cats. But a cat which shows signs of illness should be destroyed and buried.

Domestic uncleanness favours plague. The human flea (*pulex irritans*) which flourishes under such conditions, will bite both the rat and man; but it is seldom found on rats and soon dies out on them. Uncleanness also may lead to increase of rats in and about the house.

(c.) *Precautions against Rats.*

The continuous suppression or limitation of rats in a district into which rat-plague has been introduced will prevent the occurrence of human plague of local origin. Efforts should therefore be concentrated in such districts towards this end. Complete extermination of rats is perhaps impossible; but decrease of rats, short of extermination, diminishes greatly the chances of infection. Such measures must be persistent, as the rat soon breeds up to its old level of numbers, conditioned only by the amount of food supply and the activity of its enemies. Rats are intelligent, and will migrate to other districts unless the efforts at destruction are combined and systematic. In view of likely migration, medical officers of health and inspectors of nuisances, as well as private persons, in districts bordering on a neighbourhood where rat-plague exists, should make enquiries at intervals, and should submit suspected rats found dead or ill for bacteriological examination.

There are several methods of dealing with rats, but it is unwise to trust to any one of them alone, and, when practicable, all methods should be employed together. Of traps, a spring trap has been found to be the most useful kind. Poisons containing phosphorus or arsenic are effective, but they should not be laid where poultry or other domestic animals may be poisoned. The different forms of bacterial virus are useful, where chemical poisons cannot safely be employed. They are said sometimes to be uncertain in result, and it is important that animals poisoned by them should not obtain access to human food. Hunting with dogs and ferrets is a very effective method, especially in the hands of expert rat catchers. If dogs or ferrets are employed, they should be kept under observation and not allowed in domestic

* The provision of a layer of concrete under the floor, as required in the Board's Model Byelaws for new buildings in urban districts, is of importance in this connection.

dwelling. The Board of Agriculture and Fisheries are about to issue a leaflet on the subject of rat destruction, which will contain general information on the matter.

Even in districts not affected with rat-plague, nor bordering on districts so affected, the Sanitary Authority should be on the watch for the occurrence of unusual mortality among rats. If excessive mortality is observed, bacteriological examination of rats found dead should be made, and if they prove to have died of plague, steps should be taken to ensure the systematic and continuous destruction of rats. Precautionary measures of this kind are especially called for in and about docks and wharves, and also in places where rats abound, such as granaries, meat markets, slaughter-houses, piggeries, and dumping grounds for refuse. The private slaughter-houses still found in the immediate neighbourhood of dwelling-houses are a special source of danger, being commonly over-run with rats.

Fleas leave the dead rat when it becomes cold. Dead rats should, however, not be handled without precautions. Cremation is the best method of disposal of dead rats, if it can be carried out without involving delay or unguarded handling. Failing this they should be so buried that they cannot be disinterred by other animals.

Rat-catchers, as well as those engaged in disinfection of clothing, &c. can, apart from the administration of plague prophylactic, partially protect themselves by the external application of powders, &c., disliked by fleas, and by wearing puttees or gaiters and gloves.

On a previous page the importance of removing all harbourage for rats in or near houses has been emphasised. So far as possible every house should be rat-proof. It is equally important not to encourage the domestic invasion of rats by allowing morsels of food to lie on or under the floor or in ashpits.

The most important recommendations may be summarised as follows:—

- 1st.—Persistently and systematically destroy all rats.
- 2nd.—Remove and obliterate their nests, burrows, and habitual haunts, and
- 3rd.—Make each dwelling as far as practicable rat-proof, and remove all known harbourage for rats in or near dwellings.
- 4th.—At the same time do not allow waste food (whether for human beings, chickens, or other animals) to accumulate in or about the house.

Rat-plague is not necessarily accompanied or followed by human plague. Freedom from risk of plague can be secured, with almost complete certainty, by any household which acts in accordance with the directions given above.

ARTHUR NEWSHOLME,
Medical Officer.

Local Government Board,
November, 1910.

(6.)

DIRECTIONS FOR OBTAINING AND FORWARDING FOR BACTERIOLOGICAL EXAMINATION MATERIAL FROM SUSPECTED PLAGUE CASES.

[The Local Government Board, with a view to assisting in the identification of plague newly developing in a district, have arranged for bacteriological testing, without cost to the local authority, of material from the earliest suspected case or cases, or from the earliest suspected rodents, in the district. This material can be received only from the Medical Officer of Health.]

A.—*From the Living Person.*

1. Clean with soap and water and then with alcohol the skin over the bubo. When dry, or after mopping with a clean cloth, pierce the bubo with the needle of a hypodermic syringe (previously cleaned with boiling water); empty the syringe into a small phial, previously cleaned with boiling water. Collect additional exuding fluid in capillary tubes.

2. When there is a discharging bubo, collect fluid therefrom in capillary tubes as in the above case. When this discharge is not of a sufficiently fluid character for collection in this way, place some of it in a small glass-stoppered phial, previously well washed out with boiling water or with alcohol, care being taken that no alcohol remains in the phial.

3. If expectoration be obtainable, collect some in a phial in the manner prescribed in the previous sentence.

4. If the patient shows symptoms of lung disease, it should be considered whether fluid may not be obtained by aspiration under strict aseptic precautions from the lung over the affected part, and collected as above.

B.—*From the Dead Body.*

1. Cut out any inflamed lymph gland, together with some of its surrounding tissue, wrap the whole in fresh gutta percha paper, and place it in a wide-mouthed glass-stoppered bottle, previously well washed out with alcohol, care being taken that no alcohol remains in the bottle. The bottle should have the stopper well secured and sealed.

2. Obtain also a piece of the spleen, dealing with it in the same manner.

C.—*From Rats and other Rodents.*

The suspected dead animal should be immersed in a solution of a strong disinfectant before being placed in the package. By this means fleas, if any, can be destroyed.

The animal should then be packed in a tin box or a jar with a close-fitting cover, and this placed in a larger wooden box filled in with sawdust.

D.—*Directions for forwarding Material.*

1. All suspected plague material should be very carefully packed so as to avoid risk of breakage and danger of infection during transmission.

2. The material may be sent by letter post, not parcel post, if the Post Office Regulations* are complied with. The postage need not be prepaid.

3. The package should be addressed "The Medical Officer, Local Government Board, Whitehall, London."

4. A statement giving details as to the source of the material, and a preliminary account of the clinical character of the case, and other information respecting the patient should always be sent, under separate cover to the Medical Officer, Local Government Board, at the same time as the material is sent.

5. Where possible the Medical Officer, "Localise" London, should be advised by telegram that material has been despatched, specifying the route and also, if possible, the time when the material may be expected to arrive.

ARTHUR NEWSHOLME,
Medical Officer.

Medical Department,
Local Government Board,
November, 1910.

[M.D. 86.

(7.)

Letter to certain Port Sanitary Authorities:—

Local Government Board,
Whitehall, S.W.,
15th December, 1910.

SIR,

I am directed by the Local Government Board to state that they have had under their consideration the desirability of the extermination of rats caught in or near docks or wharves in order to ascertain whether any of these rats have become infected with plague.

The Board will be glad if the Port Sanitary Authority will take this matter into their early consideration with a view to having a number of rats—say 100—caught within the area of the Port Sanitary District and their condition ascertained by examination.

* Postal regulations for sending deleterious liquids or substances by ordinary letter post for medical examination.

"Any such liquid or substance must be enclosed in a receptacle hermetically sealed, which receptacle must itself be placed in a strong wooden, leather, or metal case, in such a way that it cannot shift about, and with a sufficient quantity of some absorbent material (such as sawdust or cotton wool) so packed about the receptacle as absolutely to prevent any possible leakage from the package in the event of damage to the receptacle.

"The packet so made up must be conspicuously marked 'fragile, with care,' and bear the words 'Pathological Specimen,' and also the signature and address of the Medical Practitioner or Veterinary Surgeon who sends it. The packet must on no account be sent by Parcel Post. Any packet found in the Post not packed and marked as directed, will be at once stopped and destroyed with all its wrappings and enclosures."

The Board are advised that for this purpose a bacteriological examination need only be made in instances in which post-mortem examination does not suffice to show that the animal is not suffering from plague.

The Board will be glad to learn the result of such examination.

I am, Sir,

Your obedient Servant,

F. J. WILLIS,

Assistant Secretary.

The Clerk to the Port Sanitary Authority.

(8.)

EXTRACTS FROM REPORT OF THE COUNTY MEDICAL OFFICER
OF HEALTH FOR EAST SUFFOLK UPON THE STEPS TAKEN
BY THE COUNTY COUNCIL AND THE URBAN AND RURAL
DISTRICT COUNCILS IN REGARD TO THE OUTBREAK OF
RAT PLAGUE.

First Steps Taken.

During October, 1910, representatives from the Ipswich Borough Public Health Committee and the Samford Rural District Council, with Dr. Bulstrode, of the Local Government Board, met and determined upon measures for the destruction of rats in their districts. This work was undertaken by a joint committee from the two bodies.

The East Suffolk County Council.

On November 1st, the East Suffolk County Council appointed Mr. H. Llewellyn Heath, D.P.H., Bacteriologist to the East Suffolk and Ipswich Hospital, to act until March 31st, 1911, as County Medical Officer of Health for special duties, viz.:—"To advise the Public Health Committee in regard to the detection, prevention and treatment of any disease among men or the lower animals which is of the nature of, or may be associated with, what is known as the Freston outbreak; to consult with the Medical Officers of Health of the County Districts, and to make such bacteriological examinations as may be considered necessary."

During the first week in November the following steps were taken:—

(1.) Each District Council was approached by the County Council and asked to enlist the aid of all estate agents, manufacturers, millers, farmers, and others in the destruction of rats.

(2.) The Medical Officers of Health of the County Districts were asked to instruct their Sanitary Inspectors to make systematic examinations of their Districts, and forms were

supplied on which the County Medical Officer could be informed as to the parishes visited and the observations of the Sanitary Inspectors.

(3.) Communications were sent to all medical men practising in the County detailing the symptoms of Plague in man, and advising as to notification, &c.

(4.) Through the office of the Chief Constable for the County the police were requested to report as to mortality amongst rats in certain districts, and to forward specimens for examination when required by the County Medical Officer.

(5.) Warning notices and handbills were distributed throughout the County.

Provision of Nurses.

The Public Health Committee requested their Medical Officer to make arrangements for four nurses to be immunised against Plague, who should be available for special work in the County should the necessity arise; this was done early in November.

Conference with the Local Government Board.

At a Meeting of the Public Health Committee held November 8th, 1910, it was decided that the President of the Local Government Board should be asked to receive a deputation from the County Council to discuss certain matters referring to the outbreak of Rat Plague. Consent was obtained and on November 17th a deputation composed of Messrs. A. M. Bernard, E. R. Hollond, R. Eaton White, and Dr. Crowfoot, accompanied by the Clerk and the County Medical Officer, was received by the President.

Several important subjects, which had been discussed by the Public Health Committee, were considered, and a liberal interpretation of the Local Government Board Order was given by the President.

Conference of County Representatives.

A Conference was held at the County Hall, Ipswich, on Tuesday, December 20th, between the Public Health Committee of the East Suffolk County Council and the representatives of the Urban and Rural District Councils in the County. The Chairman of the Ipswich Borough Public Health Committee and the Medical Officer of Health were also present. The following resolutions were passed:—

(1.) That in the opinion of this Conference it is still desirable that all the District Councils in East Suffolk should continue very active exertions in the destruction of rats, and that all District Councils which have not commenced operations should commence forthwith.

(2.) That the Public Health Committee be requested to collect full information as to the steps to be taken throughout the County up to the 31st of December to destroy rats and

provide against a possible outbreak of Plague, and to digest and tabulate the same for circulation amongst the District Councils of the County.

(3.) That in the opinion of this Conference statutory provision is required to compel occupiers of land and other premises to destroy rats on their premises.

(4.) That in the opinion of this Conference, the question of Rat Plague being one of national importance, the expense incurred in connection with the destruction of rats should be borne by the Imperial Exchequer.

Conference of the Medical Officers of Health of the County Districts.

A Conference of the Medical Officers of Health of the County was held at the County Hall on December 20th, 1910, at which the subject of Rat Plague was discussed. A resolution was passed that "the Public Health Committee of the County should be asked to communicate with the District Councils and suggest to them that they should take steps to enlist local assistance in the several parishes in their districts for the destruction of rats."

The Clerk of the County Council sent the following letter to the Clerk of each District Council:—

"At a Conference of the District Medical Officers of Health in East Suffolk, held here on the 20th December, it was decided to ask the Public Health Committee to communicate with the District Councils and suggest to them that they should take steps to enlist local assistance in the several parishes in their districts for the destruction of rats, and resolutions passed by the Conference embodying proposals for carrying such recommendation into effect have been forwarded to the Committee.

Acting on these resolutions I am directed to submit the following suggestions to your District Council for their immediate and favourable consideration, namely:—

(1.) That a circular should be issued by your District Council to each parish in their district—addressed to the Chairman of the Parish Council in parishes with a Parish Council, and to the Chairman of the Parish Meeting in the other parishes—requesting them to convene a Parish Meeting for the purpose of appointing a Committee to ascertain and record what is being done by each inhabitant of the parish to destroy rats in their respective occupations.

(2.) That the District Councillors for each parish should be *ex-officio* members of the Committee for that parish.

(3.) That the Committee should request one or more of their number to make the inquiries referred to in No. 1 above, and endeavour to stimulate action among the inhabitants of the parish, and also to urge the importance, when corn stacks are threshed, of each stack being surrounded by wire netting to prevent the escape of the rats.

(4.) That the Committee should report to the District Council any place where the destruction of rats will not be undertaken by private effort, such as unoccupied property.

(5.) That the Committee should report to the District Council the existence of any insanitary and other conditions likely to attract and harbour rats.

At an interview the Public Health Committee had with the Local Government Board a short time ago, the President stated that any reasonable expenditure authorised by a District Council and incurred by any authorities or persons acting as their agents might properly be defrayed as a general expense of the District Council.

In the hope that your District Council will act on the foregoing suggestions, I am directed to enclose for their use a supply of circulars to Chairmen of Parish Councils and Parish Meetings.

I shall be glad if you will inform me at an early date what action your authority decide to take."

Reports from the District Medical Officers of Health.

During November and December the County Medical Officer received frequent replies to his enquiries from all the District Medical Officers of Health in reference to mortality among rats, advice given to their Councils, steps taken, and other matters bearing upon Rat Plague and its possible communication to man. Several consultations have been held, and there has been evidenced among the Medical Officers of Health and the Sanitary Inspectors a very general desire to support the County Council's efforts. The hearty manner in which the District Medical Officers have responded to the suggestions of the County Medical Officer and replied to his enquiries is an outstanding feature in a situation which has called for much extra work from them.

Other Reports.

In addition to the reports from the District Medical Officers of Health the Sanitary Inspectors have sent reports of enquiries made by them, and have sent animals for bacteriological examination.

Great assistance has been rendered by the County Police in making enquiries in certain districts and in sending animals to the County Medical Officer for examination when requested.

By these and other means enquiries have been made in many parishes which are detailed at the end.

Bacteriological Examinations.

Several dead animals from parishes within the County have been sent to the Local Government Board. A large number of animals from all parts of the County have been examined by the County Medical Officer, the majority of these were rats, the other animals were hares, rabbits, ferrets, and three cats. Two members of the staff of the Lister Institute conducted an enquiry in November and December, and about half-a-dozen animals were examined by two other bacteriologists (Professor Woodhead and Professor Simpson). With two exceptions all the infected

animals were found in the Samford Rural District, and in the area limited by the North, West, and water boundaries of the Woodbridge Rural District.

Work done by the District Councils.

The reports received from the Medical Officers of Health as to the steps taken by their Councils up to December 31st, 1910, and other matters, in accordance with the requirements of one of the resolutions passed at the County Conference on December 20th, 1910, will be found at the end of this report. A short summary of the information is now given, with a few details not furnished elsewhere.

Two District Authorities within the County took steps to destroy rats during October, 1910, Samford and Felixstowe.

The Samford Rural District Council, co-operating with the Ipswich Borough Public Health Committee, commenced in the middle of October. The Felixstowe and Walton Urban Council took energetic steps on October 29th.

During November and December all the District Councils evidenced a greater or less activity in the matter.

The Urban Councils, taken as a whole, have responded well. To the end of December, 1910, three of these (Eye, Halesworth, and Oulton Broad) only issued warning notices and sent out notices to owners and occupiers of property urging destruction of rats. The remaining ten Urban Councils did all this, and in addition took more active steps, which will be found detailed by the Medical Officers in their reports.

In the rural areas the Councils are undoubtedly faced with greater difficulties in the destruction of rats. The majority of the Councils have contented themselves with issuing warning notices and urging householders and others to destroy rats, but in many instances this has been followed up by repeated visits from the Public Health officials.

Three of the Rural District Councils have taken more active steps; in the Wangford area a halfpenny per tail is paid for all dead rats brought to certain officials; the Plomesgate Council has had its area treated with Liverpool Virus; and in the Samford area from 20 to 30 rat catchers have been employed with great success. A most useful action of the latter Council was to supply all threshing-machine proprietors with wire netting, and to pay a small fee to fix it round all stacks threshed.

Other Work.

The Great Eastern Railway Company have shown great energy in the destruction of rats along their lines and in buildings belonging to them. At Shotley the Admiralty officials arranged for the services of a special rat catcher.

From all parts of the County we hear of the active work undertaken by private individuals. A large amount of time and money has been expended by them in the destruction of rats.

They make one complaint, a very pertinent one; it is that their work is of small permanent avail because of the apathy of their

neighbours, and this indifference is to be found in the close proximity of, and even within, the areas where the infected animals have been found. This want of unanimity of action is much to be deplored, and is very unfair to those who have willingly expended much.

Many owners of estates have been very energetic. Rat clubs are in process of formation, and the success of those started on large estates suggests that the co-operation of farmers and householders in this manner is one of the most satisfactory means of dealing with rats, which are not only now a menace to health, but a constant and direct cause of much financial loss.

Results of action taken.

It is impossible to express in figures, even approximately, the extent to which the destruction of rats has been effected during the last three months of the year. That their number is most substantially reduced is a very evident fact.

An important subject for consideration is the relative efficacy of the different methods of destruction.

Of the Virus preparations, the Liverpool, Danysz, and Ratin have been usually chosen. Opinion as to the success of the first two is not decisive, and there is no doubt that different samples vary very much in potency; in the fewer instances where Ratin was used it appeared to be the most successful. There is a strong prejudice, a sentiment which we cannot ignore, with some people against the use of Virus as a means of destruction. There are objections to the use—the great variation in virulence being the chief one—but, in view of certain communications to the Press, it is well to emphasize the fact that Rat Plague and the disease in rats caused by the microbe in the Virus are totally distinct.

Of the mineral and alkaloid poisons in use, arsenic and strychnine have been largely used; also preparations containing phosphorus as the active principle. Barium Carbonate is the poison to which the least objection can be raised—it has not been largely used up to the present in the County, but the success which has attended its use on the Continent and in America justifies its wider application here.

Where rat poisoners have been appointed they have usually availed themselves of mixtures made from their own recipes—the value of these does not depend so much upon the poison chosen as upon the adjuvant in the mixture which renders the bait “tempting.”

The practice of netting the ricks when threshed is not as general as it might be, at this time of the year it is a method of destruction which is of the greatest importance. It is not an uncommon statement that upwards of 400 and 500 rats have been destroyed in one rick by this means.

Isolation of Cases of Infectious Diseases.

Enquiring as to the provision in the different districts for isolating a case of Plague in man should it occur, the whole question of hospital provision for infectious cases has come to the

fore. Among the urban districts, Aldeburgh, Bungay, Eye, and Leiston have no provision for isolation, but the first and last named have the subject under consideration.

Among the rural districts, Hartismere, Hoxne, and Woodbridge lack means of isolation, but the latter authority is considering plans for building a hospital.

Plomesgate Council has permission to remove a Plague case to Sudbourne Hospital, and Wangford would use the Isolation Cottage at the Workhouse.

(9.)

SUMMARY OF THE BOARD'S IPSWICH RAT INVESTIGATION.

January 16th to February 14th, 1911.

STATEMENT showing, for each Sanitary District in question, the Parishes from which rats were examined; number of rats examined; rats negative on post mortem; rats negative after culture (*a*) at Ipswich, (*b*) at Chelsea (Lister Institute); and cases still undecided.

SUMMARY OF STATEMENT.

Number of Sanitary Districts from which Rats were received:—

Urban	22	
Rural	15	
	—	37

Number of Rural Parishes from which rats were received 301

Number of Rats examined:—

From Urban Districts...	1,590	
From Rural Districts...	4,481	
	—	6,071

Number of Rats found Negative on Post Mortem Examination:—

From Urban Districts...	1,565	
From Rural Districts...	4,452	
	—	6,017

Number of Rats found Negative after Cultural Examination at Ipswich:—

From Urban Districts...	19	
From Rural Districts...	24	
	—	43

Number of Rats found Negative after examination at Lister Institute:—

From Urban Districts...	5	
From Rural Districts...	3	
	—	8

Number of cultures from Rats of doubtful nature which are still under examination 3*

* Since reported negative.

District.	Number of Parishes in each Rural Dis- trict.	Number of Parishes in each Rural Dis- trict from which Rats were obtained.	Number of Rats Examined.	Number found Ne- gative on Post- mortem Examina- tion.	Number further Examined.	Number reserved for more detailed Examination.
Belchamp R.D. ...	18	18	85	85	—	—
Glemsford U.D. ...	—	—	48	45	2	1
Blything R.D. ...	45	41	425	424	1	—
Halesworth U.D. ...	—	—	25	25	—	—
Southwold Boro. ...	—	—	25	25	—	—
Braintree R.D. ...	23	8	67	67	—	—
Braintree U.D. ...	—	—	62	62	—	—
Witham U.D. ...	—	—	56	56	—	—
East Stow R.D. ...	13	13	325	324	1	—
Stowmarket U.D. ...	—	—	181	179	2	—
Aldeburgh Boro. ...	—	—	21	21	—	—
Halstead R.D. ...	16	16	115	115	—	—
Halstead U.D. ...	—	—	24	24	—	—
Hartismere R.D. ...	31	16	372	369	2	1
Eye Boro. ...	—	—	71	69	1	1
Hoxne R.D. ...	23	19	338	338	—	—
Lexden and Winstree R.D.	35	18	454	448	5	1
Wivenhoe U.D. ...	—	—	48	46	2	—
Colchester Boro. ...	—	—	323	317	5	1
Maldon R.D. ...	32	11	147	146	1	—
Burnham U.D. ...	—	—	43	43	—	—
Maldon Boro. ...	—	—	56	56	—	—
Melford R.D. ...	21	21	405	403	1	1
Sudbury Boro. ...	—	—	81	81	—	—
Mutford and Lothing- land R.D.	21	16	16	16	—	—
Oulton Broad U.D....	—	—	3	3	—	—
Plomesgate R.D. ...	40	27	487	481	5	1
Saxmundham U.D. ...	—	—	28	28	—	—
Tendring R.D. ...	27	10	327	322	4	1
Brightlingsea U.D. ...	—	—	48	46	1	1
Clacton U.D. ...	—	—	84	81	1	2
Frinton U.D. ...	—	—	58	57	1	—
Harwich Boro. ...	—	—	92	92	—	—
Walton-on-the-Naze U.D.	—	—	48	47	1	—
Thedwastre R.D. ...	20	20	395	395	—	—
Thingoe R.D. ...	47	47	523	519	4	—
Bury St. Edmunds Boro.	—	—	165	162	3	—
Totals ...	412	301	6,071	6,017	43	11

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1890	10	12	15	18	20	22	25	28	30	32	35	38	300
1891	11	13	16	19	21	23	26	29	31	33	36	39	310
1892	12	14	17	20	22	24	27	30	32	34	37	40	320
1893	13	15	18	21	23	25	28	31	33	35	38	41	330
1894	14	16	19	22	24	26	29	32	34	36	39	42	340
1895	15	17	20	23	25	27	30	33	35	37	40	43	350
1896	16	18	21	24	26	28	31	34	36	38	41	44	360
1897	17	19	22	25	27	29	32	35	37	39	42	45	370
1898	18	20	23	26	28	30	33	36	38	40	43	46	380
1899	19	21	24	27	29	31	34	37	39	41	44	47	390
1900	20	22	25	28	30	32	35	38	40	42	45	48	400
1901	21	23	26	29	31	33	36	39	41	43	46	49	410
1902	22	24	27	30	32	34	37	40	42	44	47	50	420
1903	23	25	28	31	33	35	38	41	43	45	48	51	430
1904	24	26	29	32	34	36	39	42	44	46	49	52	440
1905	25	27	30	33	35	37	40	43	45	47	50	53	450
1906	26	28	31	34	36	38	41	44	46	48	51	54	460
1907	27	29	32	35	37	39	42	45	47	49	52	55	470
1908	28	30	33	36	38	40	43	46	48	50	53	56	480
1909	29	31	34	37	39	41	44	47	49	51	54	57	490
1910	30	32	35	38	40	42	45	48	50	52	55	58	500
1911	31	33	36	39	41	43	46	49	51	53	56	59	510
1912	32	34	37	40	42	44	47	50	52	54	57	60	520
1913	33	35	38	41	43	45	48	51	53	55	58	61	530
1914	34	36	39	42	44	46	49	52	54	56	59	62	540
1915	35	37	40	43	45	47	50	53	55	57	60	63	550
1916	36	38	41	44	46	48	51	54	56	58	61	64	560
1917	37	39	42	45	47	49	52	55	57	59	62	65	570
1918	38	40	43	46	48	50	53	56	58	60	63	66	580
1919	39	41	44	47	49	51	54	57	59	61	64	67	590
1920	40	42	45	48	50	52	55	58	60	62	65	68	600
1921	41	43	46	49	51	53	56	59	61	63	66	69	610
1922	42	44	47	50	52	54	57	60	62	64	67	70	620
1923	43	45	48	51	53	55	58	61	63	65	68	71	630
1924	44	46	49	52	54	56	59	62	64	66	69	72	640
1925	45	47	50	53	55	57	60	63	65	67	70	73	650
1926	46	48	51	54	56	58	61	64	66	68	71	74	660
1927	47	49	52	55	57	59	62	65	67	69	72	75	670
1928	48	50	53	56	58	60	63	66	68	70	73	76	680
1929	49	51	54	57	59	61	64	67	69	71	74	77	690
1930	50	52	55	58	60	62	65	68	70	72	75	78	700
1931	51	53	56	59	61	63	66	69	71	73	76	79	710
1932	52	54	57	60	62	64	67	70	72	74	77	80	720
1933	53	55	58	61	63	65	68	71	73	75	78	81	730
1934	54	56	59	62	64	66	69	72	74	76	79	82	740
1935	55	57	60	63	65	67	70	73	75	77	80	83	750
1936	56	58	61	64	66	68	71	74	76	78	81	84	760
1937	57	59	62	65	67	69	72	75	77	79	82	85	770
1938	58	60	63	66	68	70	73	76	78	80	83	86	780
1939	59	61	64	67	69	71	74	77	79	81	84	87	790
1940	60	62	65	68	70	72	75	78	80	82	85	88	800
1941	61	63	66	69	71	73	76	79	81	83	86	89	810
1942	62	64	67	70	72	74	77	80	82	84	87	90	820
1943	63	65	68	71	73	75	78	81	83	85	88	91	830
1944	64	66	69	72	74	76	79	82	84	86	89	92	840
1945	65	67	70	73	75	77	80	83	85	87	90	93	850
1946	66	68	71	74	76	78	81	84	86	88	91	94	860
1947	67	69	72	75	77	79	82	85	87	89	92	95	870
1948	68	70	73	76	78	80	83	86	88	90	93	96	880
1949	69	71	74	77	79	81	84	87	89	91	94	97	890
1950	70	72	75	78	80	82	85	88	90	92	95	98	900
1951	71	73	76	79	81	83	86	89	91	93	96	99	910
1952	72	74	77	80	82	84	87	90	92	94	97	100	920
1953	73	75	78	81	83	85	88	91	93	95	98	101	930
1954	74	76	79	82	84	86	89	92	94	96	99	102	940
1955	75	77	80	83	85	87	90	93	95	97	100	103	950
1956	76	78	81	84	86	88	91	94	96	98	101	104	960
1957	77	79	82	85	87	89	92	95	97	99	102	105	970
1958	78	80	83	86	88	90	93	96	98	100	103	106	980
1959	79	81	84	87	89	91	94	97	99	101	104	107	990
1960	80	82	85	88	90	92	95	98	100	102	105	108	1000
1961	81	83	86	89	91	93	96	99	101	103	106	109	1010
1962	82	84	87	90	92	94	97	100	102	104	107	110	1020
1963	83	85	88	91	93	95	98	101	103	105	108	111	1030
1964	84	86	89	92	94	96	99	102	104	106	109	112	1040
1965	85	87	90	93	95	97	100	103	105	107	110	113	1050
1966	86	88	91	94	96	98	101	104	106	108	111	114	1060
1967	87	89	92	95	97	99	102	105	107	109	112	115	1070
1968	88	90	93	96	98	100	103	106	108	110	113	116	1080
1969	89	91	94	97	99	101	104	107	109	111	114	117	1090
1970	90	92	95	98	100	102	105	108	110	112	115	118	1100
1971	91	93	96	99	101	103	106	109	111	113	116	119	1110
1972	92	94	97	100	102	104	107	110	112	114	117	120	1120
1973	93	95	98	101	103	105	108	111	113	115	118	121	1130
1974	94	96	99	102	104	106	109	112	114	116	119	122	1140
1975	95	97	100	103	105	107	110	113	115	117	120	123	1150
1976	96	98	101	104	106	108	111	114	116	118	121	124	1160
1977	97	99	102	105	107	109	112	115	117	119	122	125	1170
1978	98	100	103	106	108	110	113	116	118	120	123	126	1180
1979	99	101	104	107	109	111	114	117	119	121	124	127	1190
1980	100	102	105	108	110	112	115	118	120	122	125	128	1200
1981	101	103	106	109	111	113	116	119	121	123	126	129	1210
1982	102	104	107	110	112	114	117	120	122	124	127	130	1220
1983	103	105	108	111	113	115	118	121	123	125	128	131	1230
1984	104	106	109	112	114	116	119	122	124	126	129	132	1240
1985	105	107	110	113	115	117	120	123	125	127	130	133	1250
1986	106	108	111	114	116	118	121	124	126	128	131	134	1260
1987	107	109	112	115	117	119	122	125	127	129	132	135	1270
1988	108	110	113	116	118	120	123	126	128	130	133	136	1280
1989	109	111	114	117	119	121	124	127	129	131	134	137	1290
1990	110	112	115	118	120	122	125	128	130	132	135	138	1300
1991	111	113	116	119	121	123	126	129	131	133	136	139	1310
1992	112	114	117	120	122	124	127	130	132	134	137	140	1320
1993	113	115	118	121	123	125	128	131	133	135	138	141	1330
1994	114	116	119	122	124	126	129	132	134	136	139	142	1340
1995	115	117	120	123	125	127	130	133	135	137	140	143	1350
1996	116	118	121	124	126	128	131	134	136	138	141	144	1360
1997	117	119	122	125	127	129	132	135	137	139	142	145	1370
1998	118	120	123	126	128	130	133	136	138	140	143	146	1380
1999	119	121	124	127	129	131	134	137	139	141	144	147	1390
2000													

