A research into epidemic and epizootic plague / by William Hunter.

1904

A RESEARCH

INTO

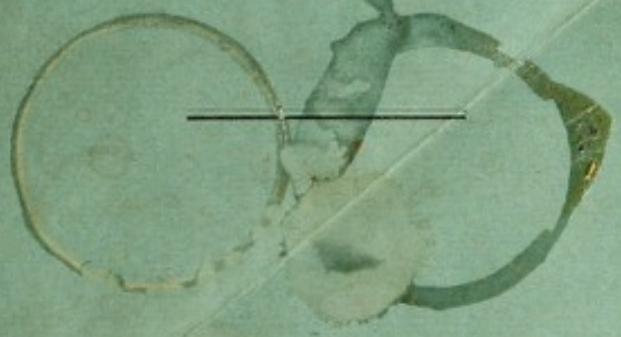
ÉPIDEMIC

AND

EPIZOOTIC PLAGUE

BY

WILLIAM HUNTER
GOVERNMENT BACTERIOLOGIST, HONGKONG



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RESEARCH

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EPIDEMIC AND EPIZOOTIC PLAGUE.

BACTERIOLOGICAL SUB-DEPARTMENT,

HONGKONG, *9th June*, 1904.

SIR,

I have the honour to submit, for the consideration of His Excellency the Officer Administering the Government, the following Special Report on the Results of my Researches into Epidemic and Epizootic Plague.

I have, &c.,

WILLIAM HUNTER,
Government Bacteriologist.

The Honourable

J. M. ATKINSON, M.B., ETC.,

Principal Civil Medical Officer,

etc., etc., etc.

PREFACE.

In forwarding this report to the Government I would mention that I have been for many years a firm believer in the fact that infection frequently occurs through the gastro-intestinal tract. I would here repeat what I stated in my report to the Government on the prevalence of Bubonic Plague in the year 1896:—

"The main channel by which the bacillus gains access to the body appears to be by the digestive tract.

In most cases the mucus membrane of the alimentary tract, from the stomach downwards, has been found distinctly hyperæmic, the membrane being thickly coated with mucus and presenting petechiæ and inflammatory patches. The mesenteric and retro-peritoneal glands in all cases were inflamed and in many cases surrounded by sanguineous effusion, the gland tissue itself being softened and crowded with plague bacilli. In many of the cases these were the only post-mortem appearances to be found.

Rats, mice, monkeys, pigs and fowls have been proved to have acquired plague after having been fed with fragments of organs of animals that have died of the disease. The fæces of those attacked undoubtedly contain the plague bacilli.

Infection of the skin (inoculation) occurs but very rarely, if this were the frequent mode of infection we should find more often inflammatory affections of the skin, as when animals are infected subcutaneously well marked inflammatory changes at the seat of inoculation always occur.

Again, the external glandular affections (buboes), from which the disease derives its name, are not met with as a rule until some three or four days after the period of invasion.

If infection by the skin is the rule one would expect, as WILM has pointed out, that axillary buboes would be quite as common as inguinal ones; this however is not the case.

As against the theory that the channel of reception of the bacillus is the respiratory tract (*i.e.*, infection through the air), may be adduced the immunity of those who attend the patients and of the Sanitary Staff who superintended and were engaged in the inspection and disinfection of the infected houses. The plague bacillus has not been detected in the air, many examinations were made of the air of the wards at the Plague Hospital but always with negative results. The plague bacillus also does not survive dessication.

The main channels of infection therefore appear to be the digestive tract and the skin.

In 1896 many cases occurred without the formation of buboes, during the height of the epidemic the percentage of these cases was twenty and towards the end as high as twenty-seven.

In all cases the disease was diagnosed as plague by demonstrating the presence of the bacillus in the blood or by culture experiments of the blood, fæces or urine."

As regards the *microscopical examination of the blood and the diagnosis of plague*, this method was perfected last year by the examination of blood films according to Ross' method, in this way much more of the blood is examined at one time and in typical cases of the disease one always finds plague bacilli present.

Plague a Septicæmic Disease.

The reasons given in this report for considering plague a septicæmic disease appear to be conclusive, they are briefly:—

(i.) The fact that by Ross' method plague bacilli are found in the blood in living cases in considerable numbers;

(ii.) The presence of plague bacilli in bubonic cases before the formation of the bubo; and

(iii.) The presence of plague bacilli in the blood of patients convalescing from this disease.

Avenues of Infection in Plague.

Dr. HUNTER's investigations lead him to the conclusion that it is chiefly through the alimentary canal that the bacillus enters the body, this raises the important question of the possibility of *food infection*.

In the Annual Report of the Medical Department for 1898 I drew attention to the fact that outbreaks of what was known as rinderpest in cattle had preceded the epidemics of 1894, 1896 and 1998.

In the earlier months of 1898 the neighbouring provinces of Kwantung and Kwangsi were overrun with this disease which killed off large numbers of cattle. Dr. MACDONALD of Wenchow wrote me in that year "that preceding the outbreak of plague in that town there was an epidemic of rinderpest in the native cattle."

Again in 1896 an epidemic occurred amongst the pigs imported to the Colony from Hoihow. Dr. WILM and myself examined several of the pigs and the symptoms and post-mortem appearances found were similar to those met with in cattle which had died of rinderpest. In the light of recent researches these diseases must have been of the nature of *hæmorrhagic septicæmia*. A similar epidemic occurred amongst pigs in and around Canton preceding the outbreak of plague there in 1898.

In 1899 Cheung Chau, a small island sixteen miles from Hongkong, was attacked with plague and an epidemic of a similar nature prevailed amongst the pigs on this island prior to the outbreak in man, and distinct evidence was obtained that pigs which had died of this disease had been used as food. Suggestive as these facts were of the possibility of infected food spreading the disease it was impossible for us with our then limited staff to follow up these investigations.

On the arrival of Professor SIMPSON in 1902 I told him of these outbreaks and particularly of the one at Cheung Chau and suggested how important it would be to carry out experiments in regard to the susceptibility of animals to plague infection.

The results of these experiments are given in Professor SIMPSON's Report on the Causes and Continuance of Plague in Hongkong published in 1903. They proved that pigs, calves, sheep, monkeys, fowls, &c., are more or less susceptible to plague of a fatal nature; that they take the infection by feeding as well as by inoculation and that the type of plague induced by feeding is usually septicæmic.

Dr. HUNTER, as his report shows, has further investigated the possibilty of the infection being communicated by way of food.

He has shown that the plague bacillus grows exceedingly well in media, prepared with rice. He has found plague bacilli in the cheapest and most inferior quality of rice; rats fed with this rice contracted the disease, guinea pigs fed with it gave similar results, so that there can be no doubt that infected rice may spread the disease. This quality is used as food by the poorer class of Chinese.

The spread of plague infection by insects is an interesting chapter, this occurs indirectly by infecting food and household utensils.

Occurrence of Disease in Animals.

This report shows conclusively the important part played by rats, that are suffering from plague, in conveying the infection to man. The presence of chronic rat plague is dealt with very fully and it is this chronic rat plague which Dr. HUNTER thinks bridges over the intervals between successive epidemics. Again other animals such as cats, fowls, calves, sheep and pigs, &c., are susceptible to plague infection and may become elements of danger.

He concludes that plague is primarily epizootic and within a week or fortnight becomes epidemic in man.

Climatic Influences.

Dr. HUNTER does not think these have any effect on the progress or otherwise of the disease. The fact that in Hongkong the epidemics always subside when the mean daily temperature exceeds 82.° F. may be accounted for by the fact that the higher the temperature the shorter the life of the bacillus.

Prophylaxis.

The first thing appears to be to attack the rats. The recent results obtained by Professor ROUX in producing an epidemic amongst rats in the Department of Charente in France by means of a virulent strain of DANYZ's bsacillus justifies one in the hope that we may yet be able to rid the Colony of these pests.

Another measure almost of as great importance to my mind is the *general cleansing of the native tenements*, which has been carried out so successfully in this Colony during the past two years; associated with this must be the thorough disinfection of all infected premises.

With regard to prophylaxis, Dr. HUNTER raises the question of the possibility of the occurrence of latent cases of plague in human beings; if this be true, viz., that an individual apparently in good health may yet be harbouring enormous numbers of plague germs, one can easily understand how such an one might be scattering the germs broadcast.

I have said enough to show that this report is well worth perusal and contains evidence of much careful investigation into this disease from every point of view.

J. M. ATKINSON,
Principal Civil Medical Officer.

HONGKONG, 21st June, 1904.

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WILLIAM HUNTER.

The Symptom Complex of Plague.

It is not my intention to enter into any detailed description of the symptoms and physical signs of Plague. Many excellent accounts of these have been given by those interested in the disease. The phases of the disease in Hongkong are in accordance with those found in other parts of the world.

My reason for discussing the clinical aspect of plague is, that certain symptoms complained of by individuals during the earliest stages of the disease, appear to have attracted but scant attention. It is unfortunate that these have not been fully investigated, because from my researches, some of these symptoms are indicative of the starting point of the disease, and the deductions drawn from their appearance are verified by the results obtained after death.

It would appear that the majority of medical men, actively engaged in diagnosing the presence or absence of plague infection in man, have restricted their enquiries to the prominent symptoms and signs of the disease, paying but little attention to the exact mode of onset of the affection, and such symptoms which may have been present previous to the occurrence of fever—a bubo, etc.—or even before they come under the eye of the plague expert.

The diagnosis of cases of plague has to be made as soon as possible. During plague epidemics, the time at the disposal of those in charge of plague patients is fully occupied. Little or no attention can be paid to the detailed clinical aspect of the cases. Consequently in plague infected localities, the clinical observations have rarely gone beyond the classical symptoms of the disease—namely, those upon which the physician depends in order to arrive at a correct diagnosis. Again the clinical features presented by cases of plague are not so carefully enquired into now-a-days, owing to the introduction of more rapid and accurate means of arriving at a diagnosis, namely, *the demonstration in the tissues of the causal agent itself—the Bacillus pestis.*

In connection with my researches into the clinics of plague, I have asked myself, whether those well known symptoms of the disease are the *only* important evidences of plague, or whether there exist others, and if so, do these add anything to our knowledge of the pathology of the disease? The B. pestis does not produce a soluble toxin. The poison which it produces is intimately bound up with the bacterial protoplasm. It is of the nature of a protein. It is very lethal. Widespread evidence is present, in every case of plague, of its powerful action. All organs and tissues of the body are profundly altered. The circulatory apparatus of the body is one of the systems most affected by the plague poison. All cases of plague show an early and extreme cardiac weakness. The heart beat is quickened, the pulse dicrotic, and becoming towards the close of life threadlike.

The exact pathology of this action of the plague poison on the cardiac apparatus is as yet undetermined. It would appear to act centrally. In all cases there occur marked chromatolytic changes in the nerve cells of the brain. The appearance presented by the central nervous tissue in a case of plague, is similar to that found after death from acute intoxication due to some poison. The fever curve is far from typical. It usually rises suddenly to an appreciable height, and subsequently maintains an elevated position with morning remissions. Such remissions may be extreme. As WILM says, no criterion of the severity of a case is afforded by the temperature chart. Patients may be supposed to be progressing favourably towards recovery and the physician in charge may have pronounced the prognosis as good, yet on his arrival the following day, he is told that the patient died suddenly during the night. Such is the history of many cases. It shows the dangers of giving an early prognosis in cases of plague. Experienced plague physicians avoid as much as possible the question of prognosis until the patient is well into a state of convalescence. It is the cardiac apparatus which one has to deal with, and it is to this system that the physician must exert his best skill.

Again intense headache with a feeling of giddiness is one of the earliest complaints. This is usually accompanied by persistent vomiting. The patients when brought to Hospital often appear as if intoxicated with alcohol. The sensorium is profundly affected, often accompanied by somnolence and great prostration.

The speech is also regarded as characteristic. The conjunctivæ are usually intensely injected and often there is marked photophobia. Jerking movements of the muscles accompanied by a sort of intention tremor are usually present in typical cases.

These are among the most important symptoms usually described in characteristic cases of plague. They are followed by the development of the so-called types of the disease, namely, the bubonic, pneumonic and septicæmic plagues. These clinical symptoms, aided by the demonstration of the specific cause in an individual complete the diagnosis. As already noted, such diagnoses have to be made as rapidly as possible during an epidemic. There is a constant influx of patients and with the preparation of the various necessaries requisite for their treatment, the time of plague officers is fully occupied. Consequently I venture to state that in the majority of cases a careful note of all the initial manifestations of the disease has not been made. Again trustworthy accounts of the earliest symptoms of the disease are difficult to obtain. The majority of patients are not brought to Hospital until a day or two after the onset of the disease, and even on reaching the Hospital the sensorium of these patients is so altered that a reliable account of the onset of the disease is either unattainable on untrustworthy.

The initial manifestations of the disease, which I regard as having been to a great extent lost sight of, *are those arising from the gastro-intestinal tract.* In the various Reports on Plague, including those of the Commissions, mere mention is made of the occurrence of diarrhœa and vomiting. Their appearance is apparently regarded as ordinary symptoms occurring during the advent of an acute infectious disease.

Wilm, however, in his Report on Plague in Hongkong in 1896, describes shortly the occurrence of such manifestations and lays some stress upon them. On page 9 of this report we find the following:—"The symptoms of disorder of the digestive tract were very numerous. At the outset of the disease the tongue usually became swollen, bright red at the tip and edges, and was covered with a greyish white fur. Usually on the second or third day of the disease, the fur became brownish or black, and dried in a crust. The tongue becomes cracked and fissured so that it soon resembles that seen in typhus or in enteric fever about the third week of the disease. The lips soon become dry and often fissured, the mucous membrane of the mouth and pharynx was usually bright red. The appetite disappeared. There was frequently uncontrollable vomiting and great thirst, with a painful sensation of heat in the stomach and the lower part of the abdomen. The vomit was sometimes watery, sometimes bilious, sometimes like coffee grounds. Diarrhœa was frequent at the outset and again in the later stages of the disease . . . . . Blood, mucus, and epithelium frequently appeared in the stools."

Wilm concluded, as the result of his observations, that an intestinal type of plague existed. He says "that in 20 % of the cases, the intestinal symptoms were so predominant, that the illness had to be regarded as essentially an intestinal affection."

Wilm's results do not appear to have attracted a great deal of attention. The members of the various Indian Plague Commissions do not deny the existence of such a type of the disease, yet were unable to support it. Such a type of plague is put down by them as a form specially met with in Hongkong, and of no great importance so far as the pathogenesis of the disease is concerned.

On my arrival in Hongkong, I was prepared to meet with the classical types of plague, as laid down in the various Reports. My experience of plague at the Mortuary confirmed the presence of these types. At the same time I was struck by the appearances presented post-mortem. According to the type of case examined, buboes, pneumonias, etc., were found and the general morbid alterations in the tissues and organs more or less harmonised with my expectations. *What seemed to me to be wanting in the reports* on the pathological aspects of these cases, *was a description of the appearances presented by the gastro-intestinal canal.*

In the vast majority of cases examined post-mortem, a careful examination of the gut showed the presence of pathological change. Previous to the disturbance of the contents of the abdomen, one could observe on opening the peritoneal cavity, patchy congestion of the stomach and intestines. The vessels leading to

and from the gut were engorged and in their neighbourhood small haemorrhagic extravasations were frequently found. On examination more closely, the gut was found to be thickened, œdematous with occasional haemorrhages between its different tunics. The mucous membrane was usually much congested, thickened and pulpy. Numerous extravasations of blood of varying size were found, and in some places actual erosion and ulceration had taken place. In a few cases the lumen of the gut was found to contain brownish black tarry material, evidently blood changed in colour owing to the action of H_2S. The changes were most marked in the lower small intestine, and gradually diminished in severity towards the stomach. In the stomach and duodenum the changes were sometimes extremely pronounced, but such usually occurred in patches of limited extent. Again enormous haemorrhages are frequently found into the mucous membrane of the stomach. On examining the mesentery and contained lymphatic glands, changes were also found. The mesentery itself was often considerably thickened and sodden from œdema, with marked capillary injection. Large haemorrhages were also found.

The lymphatic glands were also affected. They were enlarged and congested, and on section were found to be œdematous and often haemorrhagic. All these changes will be discussed at greater length under the results of post-mortem examinations.

Having satisfied myself as to the more or less constancy of well marked intestinal changes in all varieties of the disease, I looked for assistance or confirmation of the presence of these lesions. The literature on plague was of little value. Beyond the mere mention of certain pathological changes in the intestine, no further comments are made. I consulted Professor SIMPSON, pointing out to him these changes. He agreed with these statements which I have just made, and told me that, to the naked eye, the appearances of plague corpses were similar to what he had seen in South Africa and India, and from the presence of these changes in the gastro-intestinal tract, he was more inclined than ever to support the gastro-intestinal origin of the disease.

Again WILM's reports were of use. My own post-mortem results agreed in the main with those of this observer.

In order to obtain more definite information in regard to these intestinal changes, I appealed to the clinical side of plague, hoping thereby to obtain evidence by the presence of symptoms of an affection of the gut. My help therefore, had to come from the various reports furnished by the Medical Officer in charge of the Infectious Diseases Hospital and the Superintendent of the Government Civil Hospital, both of whom had most experience with cases of plague during the last epidemic.

The presence of symptoms indicative of marked affection of the gastro-intestinal tract in plague do not appear to have called for comment by the Medical Officer in charge of Kennedy Town Hospital. Mention is made of the presence of vomiting and diarrhœa, but no details are given in the notes on the cases as to the date of onset of these symptoms, their duration, character and severity, etc.

It is interesting, however, to find that symptoms were found present in the majority of the cases, pointing to some affection of the alimentary canal.

During plague epidemics, a considerable number of individuals, complaining of indefinite symptoms, apply to the Government Civil Hospital for treatment. Many of these, after clinical examination turn out to be early cases of plague, and are forthwith despatched to the Infectious Diseases Hospital. Dr. BELL, the Superintendent of the Government Civil Hospital, tells me that many individuals have applied for treatment during the earliest stages of the disease, at a time when the history of the illness could be obtained with a certain amount of accuracy. Being specially interested in the question of the early diagnosis of the disease, Dr. BELL noted carefully the various symptoms complained of by each individual patient. On making enquiry as to the primary symptoms complained of by plague patients, Dr. BELL furnished me with the notes of the cases which came under observation and, as will be seen, *he has been able to assist me greatly in regard to the question of the occurrence of marked evidence of an affection of the gastro-intestinal tract in plague.*

It would be impossible to detail in this report, the notes of all the cases which are of interest in regard to this question. I shall limit myself to the histories of the following four cases, these being representative of the question at present under consideration :—

Case No. I.—F. A., admitted to the Government Civil Hospital on the 17th March, 1903, complaining of severe diarrhœa. Temperature on admission, normal. The blood was examined with negative results. The character of the stool was loose, bile stained and foul smelling. Nothing characteristic was found in the stool when examined microscopically. The number of stools on the day of admission was 6. On the 18th 4 stools, on the 19th 4 stools, and on the 20th he had 2 stools. All the stools were of the same character as described. The temperature was still normal on the 20th. On the evening of the 20th it suddenly rose to 102° F. The diarrhœa was still present. On the 21st the evening temperature was 103° F., diarrhœa still present. On the 22nd the temperature was 103° F, diarrhœa small in amount. The blood was examined by the method recommended by Ross for malaria, and a number of oval, bipolar shaped micro-organisms was found. These were regarded as plague bacilli, and the patient was removed to Kennedy Town Hospital. Here, he complained of severe headache, and sleepiness. The tongue was thickly furred, and in general, the patient presented all the signs of severe plague infection. No bubo developed. *He went through an extremely severe attack of plague of the septicæmic type.*

Case No. II.—S. S., a police constable, was admitted to the Government Civil Hospital on 3rd June, 1903, complaining of vomiting and diarrhœa of a day's duration. On admission, the dejecta were found to be watery, bile stained, and foul smelling. The tongue was furred. The temperature was 100° F. The blood was examined by Ross's method, and large numbers of bacilli identical with the B. pestis were found. On the strength of this, the patient was removed to the Infectious Diseases Hospital, where *a severe and typical bubonic plague developed.*

Case No. III.—T. K., a Chinese police constable, was admitted to the Government Civil on the 4th March, 1903, complaining of severe "colic," vomiting and constant watery diarrhœa. The bowels opened twice soon after admission, and the dejecta were watery and brownish yellow in colour. Nothing abnormal was found in the stools. The patient looked very pinched, ill, and somnolent. The temperature was 99° F.

On the 5th the temperature was still 99° F. The patient was very sleepy and dull. He complained of severe headache. The tongue had become thickly coated. The diarrhœa was still profuse and of the same character. The blood was examined as in other cases. Bacteria morphologically identical with the B. pestis were found. He was removed at once to Kennedy Town Hospital where *he passed through a typical attack of plague of the bubonic type.*

Case No. IV.—H. T., a Chinese coolie, was admitted to the Government Civil Hospital on the 16th March, 1903, complaining of cramps in the abdomen, headache, vomiting and diarrhœa. On admission, the temperature was 100.8° F., the tongue was foul, headache was constantly complained of, and vomiting and diarrhœa continued severe. Nothing abnormal was found microscopically in the stools. They had the usual naked eye appearance. During the first 24 hours after admission, the patient had 22 stools. The blood was examined as in other cases and organisms identical with plague bacilli found. He was transferred to Kennedy Town Hospital and *developed into a typical case of septicæmic plague with no bubonic formation.*

These cases are illustrative of the mode of onset of plague. Many others presented the same train of symptoms previous to the development of the typical and well recognised signs of plague. From these and other cases *it is evident that diarrhœa and vomiting are among the early symptoms of plague.* They may be present alone and the individual affected able to go about his daily duties. Sometimes they are accompanied by headache and a feeling of sleepiness but these may be absent.

Again, during this initial stage, there may be no elevation of the body temperature. The reports on the microscopical examination of the dejecta say that nothing abnormal was found. Hoards of various micro-organisms were probably present, but the diagnosis of the presence of the plague bacillus in such a medium would be quite impossible. The diagnosis of plague was made absolute by the microscopical examination of the blood. The thick film method of blood examination advocated by Ross for malaria was applied by Dr. BELL to cases of plague. The results were satisfactory and in the majority of cases of a convincing nature.

With a patient complaining of indefinite symptoms, as headache, diarrhœa and vomiting and the finding of oval shaped and bipolar bacteria which decolourised by GRAM's method in the thick blood film, during an epidemic of plague in the Colony, the diagnosis or at least provisional diagnosis could only be that of plague.

The presence of the B. pestis in the blood stream of patients suffering from plague is recognised. It is denied, however, that these bacilli are present in the blood during all the stages of the disease. The most modern views on the question are that in the bubonic variety of the disease, plague bacilli are found in the blood only just before death. That is to say the disease becomes septicæmic during the agonal period and numbers of B. pestis appear in the blood. Some observers go so far as to assert that there exists no such thing as septicæmic plague. Again in the pneumonic variety of the disease, the same views are held, namely, the tendency of the disease to become septicæmic just before death.

That these statements are founded upon a firm basis, is by no means obvious. The results obtained by different observers would appear to vary considerably. WILM was able to find plague bacilli in the blood stream of cases of all varieties of the disease some considerable time before death.

The results obtained by other observers, however, have been more or less negative. From these cases which have just been described, *it is seen that the diagnosis of plague was made from a microscopical examination of the blood during the initial stages of the disorder, and further the method employed gave extremely reliable results.*

This is in direct opposition to the views held by the majority of plague workers of the present day. Their views I have only just mentioned.

The presence of the B. pestis in the blood of plague patients during the early stages of the disease, *appears to me to be of the greatest importance.* Further the thick blood film method of Ross applied to plague haematology, is a most useful addition to the methods of diagnosis of cases of plague. Dr. BELL has told me that these bacilli have been found in the blood during the initial stages of all types of the disease, namely, the bubonic, pneumonic and septicæmic.

In the septicæmic types of the disease (and as already mentioned, the existence of this form of plague is almost denied by some), the demonstration of the causal agent in the blood excites no surprise, but when we find that similar results are attainable in the other varieties of the disease, *our ideas in regard to the pathology of plague must necessarily change.* Even granted that the method is not absolutely reliable (and no method in bacteriology is infallible), the finding again and again of plague bacilli in the peripheral blood stream during the early stages of the disease, *is a new fact*, and *one which alters the present day conceptions of plague.* That the micro-organisms found in the thick blood films were plague bacilli, there can be no doubt.

At the commencement of Dr. BELL's examinations of the blood of suspicious cases of plague, many of the slides were shown to me, and I must confess, that I was sceptical as to the reliance, which could be placed on the method as one for

purposes of diagnosis. With further observation of such preparations, coupled with the results obtained in all types of the disease, often in the absence of an examination of the patient, and the negative reaction obtained when GRAM'S method was employed as a precautionary test, I feel convinced that this method of Ross applied to the hæmatology of plague opens up to us an entirely new field of research into the pathology of plague and will alter our views as regards the types of the disease, *if such distinct varieties of plague are existent.*

Recently Dr BELL published a short note on this method in the British Medical Journal (March 1904, p. 544). He says: "I have examined numbers of cases, mostly on the first or second day of illness, and in every case, the result has been positive." Further he comments thus: "a case can be diagnosed almost as easily as a case of malaria."

In my opinion *these expressions are too absolute.* The method is not absolute. One may easily fall in error unless great care is exercised in the preparation of these thick blood films. Again *unless a fair number of these bacilli are found present, the diagnosis should be withheld until a more favourable blood film is obtained.*

The method of finding plague bacilli in the peripheral blood during the phase of the disease is of the greatest interest, and the results obtained are more or less in direct opposition to the views expressed by most scientists in regard to this question.

This is so entirely new that I would not support such a result, in the face of so great an amount of contrary evidence, had I not convinced myself of its actual presence. The method has been successfully prosecuted at the Government Civil Hospital, and I believe the Medical Officer in charge of Kennedy Town Hospital has reported favourably upon it. From this result, it would appear that the views held in regard to the bacteriology of plague must alter in a manner *similar* to those held a few years ago in regard *to typhoid fever.* The B. typhosus was, up until a few years ago, supposed to have an extremely limited distribution in the body. The organism had scarcely ever been found apart from lymphoid tissues. Typhoid was regarded as a disease of the abdominal cavity. With extended research, all this has become changed. Typhoid fever is now recognised as a septicæmia, with the presence of the B. typhosus in the blood, and the majority of the symptoms and physical signs of the disease, are regarded as being due to the actual presence of the specific organism itself, rather than to the absorption of poisons produced by the bacillus at some distance.

Plague, viewed in this light, would appear as a septicæmia—a disease caused by the B. pestis, which is present in the blood stream and can multiply there. *This septicæmia may remain as such,* or *in other cases may be accompanied by the formation of one or more so called bubonic swellings in connection with certain groups of lymphatic glands,* or again, *may be accompanied by secondary pneumonic processes in the lung.*

Such a view of the disease would account for the majority of plague cases. It must not be forgotten that there *probably exists another type of the disease,* distinct from that commonly found, namely, the *primary pneumonic pest,* which is *caused by direct inhalation of virulent B. pestis.* From all researches, it appears that *this inhalation disease is something different,* and the distinguishing features of this form, and the significance of its presence are discussed under a separate heading.

For purposes of comparison, it will be of use to sketch briefly the present day opinions in regard to the pathology and bacteriology of the disease.

Plague, with all its so called types or varieties is caused by the specific organism, known by the name of the B. pestis, and, were it not for the constant presence of this characteristic micro-organism in all the different manifestations of the disease, there would, as in past ages, be a tendency to regard the principal types of plague as distinct diseases.

The general consensus of opinion is that the bubonic type of plague is the standard variety of the disease. The causal agents are found in the bubo, but not in the blood. Throughout the disease the bacilli are pent up in the bubo. The

affection only becomes septicæmic before death. If recovery takes place, the bacilli never reach the blood. During the agonal period, the blood becomes full of plague bacilli, the organisms are found in the secretions and excretions of the patient. In the fæces, urine, the bile, and the terminal lung œdema, plague bacilli may be found in enormous numbers. *Such is the general trend of opinion in regard to bubonic plague.*

By some it is admitted that when using large quantites of blood for examination, the B. pestis may be found, but that such a result does not justify the conclusion that the disease is of septicæmic nature. On the evidence such a conclusion is quite justifiable. As to the methods, however, through which one or two plague bacilli have been demonstrated in the blood of patients suffering from bubonic plague I am unable to speak.

What is certain, however, is, that in the films prepared according to the method of Ross, and showing the presence of plague bacilli, these organisms were always present in considerable numbers. From the total number of these found in a single drop of blood, one is compelled to conclude that they must be present in great force in the general circulation. Again such organisms are present in the blood frequently previous to the development of a bubo.

Another interesting fact in connection with the septicæmic nature of plague, is the presence of plague bacilli in the blood of patients who are convalescing. Such a result has been found on several occasions, and just as I write, a case of this kind has come under my notice, through Dr. Koch, the Medical Officer in charge of the Plague Hospital. The patient has passed through a severe attack of plague. He is at present convalescing, and an examination of a drop of his blood, stained with methylene blue and eosin, shows the presence of numerous typical bipolar and oval shaped plague bacilli.

From these considerations I am inclined to regard plague as *a septicæmic disease ab initio*. The organisms multiply in the blood, they may be found in the blood at the commencement of the illness, and may even persist in the blood for an indefinite time during convalescence.

The presence of plague bacilli in the blood, previous to the development of the bubo, is of great interest in regard to the modes of entry of the organism into the human body. Such has been the results of my observations of the bubonic type of plague. It is my object now to bring forward further evidence in favour of the views just expressed. These views are, so far as I understand, original, and are stated because of the results which have been obtained and verified by myself over and over again.

When I arrived in the Colony a little over two years ago, I met with plenty of examples of the classical bubo in all its various situations. I was well aware of the results of the various researches into the subject, and judging from the amount of work which had already been done by many eminent bacteriologists, I did not see that much could be added to the prevailing doctrines of the pathology and bacteriology of the disease. I was cognisant of the fact that the blood had frequently been examined in all varieties of plague, and that rigid bacteriological technique had been used. Considerable quantities of the blood—5-10 c.c.—had been used for purposes of cultivation. As has already been mentioned, plague bacilli have been found in the blood of such cases, *e.g.*, in bubonic plague, but the reports are in harmony in declaring that the bacilli found were few in number, in fact so scarce, that one, under the circumstances, is not justified in pronouncing the cases to be of a septicæmic nature.

I think, however, when one finds, in a single thick drop of blood, derived of its hæmoglobin and subsequently stained, numerous oval shaped, bipolar, non-grain staining bacteria, in the earliest stage of this type of the disease, and frequently previous to the development of the actual bubo itself, we can imagine how large a number of these same micro-organisms must be present in the general circulation. In fact, in order that such a number of plague bacilli can be found in the blood, the organisms must multiply. With these facts before one, the conclusion seems justified that *Bubonic Plague is in reality Septicæmic Plague* in which the organism reaches the general circulation to begin with, multiplies there, producing the symptoms of the disease, and that the actual bubonic manifestation is an altogether secondary development. Further there are other points in favour

of the view that the plague bacillus is more or less constantly found in the blood in plague. Skin eruptions of various kinds are frequently met with in plague. These may be of the nature of papules, vesicles or pustules. Some of these pustular forms are of such a size as to resemble boils or carbuncles. Such skin eruptions usually appear in the following way. A small reddish or brown spot, varying in size from a pin's head to a pea, appears on the skin. It has a hot or burning feeling. The spot becomes indurated, slightly elevated, and surrounded by halo of bright red congestion. It develops into a vesicle, which also varies much in size. The contents of this are cloudy, and contain plague bacilli in considerable numbers. The vesicles soon become infected with ordinary skin micro-organisms, and the contents become pustular. The surrounding halo of congestion increases in circumference, the induration is more marked, and according to the severity of the process, the lesion may be likened to a pustule, boil or carbuncle.

Such vesicular and pustular manifestations are by no means uncommon in bubonic or other varieties of plague. The vesicles contain plague bacilli. The pustules usually contain large numbers of ordinary pyogenic cocci. Plague bacilli which were present originally, have usually disappeared, the condition resembling that found in suppurating bubonic swellings. I regard these *papular, vesicular and pustular eruptions as evidences of local growth of the B. pestis.* The condition, I presume, is similar to that found in enteric fever, where the typhoid rash is the result of focal multiplication of typhoid bacilli. These eruptions often appear scattered over the skin, and in cases where a well developed bubo is present, they have nothing to do with the point of entry of the infection. They are evidence of blood infection and support the septicæmic theory of plague.

At the same time *such eruptions may occasionally represent the point of inoculation of the plague virus.* Cases of this are occasionally met with. An excellent instance of the occurrence of this mode of infection came before my notice about two years ago, whilst engaged with Professor SIMPSON in carrying out an experimental research into the question of the relative susceptibility of different animals to plague.

The details of the case are as follows :—A Chinese butcher was engaged by us to assist in performing the post-mortem examinations on the experimental animals which had succumbed to plague. On one occasion, a post-mortem examination was being held on a pig which had died of severe septicæmic plague. The butcher accidentally scratched the back of his right hand with the broken end of one the ribs. The injury was slight and just tinged with blood. It was washed, sucked and disinfected. It caused him no inconvenience at the time. He discontinued the post-mortem at once. Two days later, the man complained of sickness and diarrhœa, with severe headache and general weakness. He ascribed the symptoms to malaria from which he frequently suffered. On the following day he felt hot and generally uncomfortable. The injury or scratch on the back of his right hand felt sore and burning. His right arm felt weak with shooting pains in the muscles. The scratch showed nothing particular. Very slight induration was made out but this was ascribed to the effect of strong antiseptic solutions. Being suspicious of plague the man was at once isolated. Slight traces of lymphangitis were found extending up the forearm. On the following morning a small vesicle had developed over the site of the original scratch. The surrounding skin was red and congested and indurated. The lesion was extremely painful. The lymphangitis was more marked and had extended to the arm. The axilla was tender, but no bubo had developed. The temperature was 102° F., the eyes congested, the tongue coated and he still complained of slight diarrhœa. The contents of the vesicle were examined bacteriologically and numerous plague bacilli found. The blood was also examined with a positive result. The man was treated in the Plague Hospital. A bubo developed in the right axilla. The original vesicle dried up under proper treatment and the lymphangitis disappeared. A few days after his admission to Hospital, several small vesicles developed on his legs. All of these resembled the original one on the hand. All contained plague bacilli. The man presented all the symptoms and physical signs of plague in its bubonic form and died 7 days after admission of cardiac failure. Such a case is interesting from several points of view, namely :—

(*a.*) The exact localisation of the point of infection.
(*b.*) The pathological lesions at the point of infection.

(*c.*) The occurrence of lymphangitis.

(*d.*) The demonstration of plague bacilli in the vesicle, and in the blood 24 hours later.

(*e.*) The late appearance of the bubo.

(*f.*) The occurrence of secondary vesicles, containing plague bacilli.

(*g.*) Noteworthy is the presence of initial symptoms pointing to an affection of the gastro-intestinal tract.

This case is a good instance of bubonic plague with undoubted blood infection. The formation of the bubo was certainly a secondary process if we consider the exact date of the onset of the illness. The bubo did not develop for several days, during which, there was headache, diarrhœa, vomiting somnolence and plague bacilli in the primary vesicle and in the blood. Many similar instances of this were found during the epidemic of 1903. The patients came to Hospital complaining of headache, vomiting, and diarrhœa. The blood was examined for malarial parasites by the thick blood film method, but instead of these parasites, appreciable numbers of plague bacilli were found. At this time the buboes had not developed. The cases were transferred to Kennedy Town Hospital where typical bubonic manifestations showed themselves in a very short time.

Another evidence of severe blood infection in this case of bubonic plague, was the occurrence of crops of vesicles in other parts of the body, these containing plague bacilli.

The occurrence of papules, vesicles, etc. on the skin in cases of plague is of great interest from the point of view of blood infection. In the majority of cases the B. pestis can be isolated from such eruptions. Sometimes the plague bacillus is present in pure culture, but this is rare except during the initial stages of such eruptions. In the vesicular stage, the B. pestis is often mixed with staphylococci, or streptococci, and in the pustular stage, ordinary pyogenic bacteria form the majority of micro-organisms present in the pyoid discharge. The larger pustular eruptions remember one of boils or even carbuncles, but a slight acquaintance with their anatomy shows one that they are of an entirely different pathology.

Eruptions in plague vary in degree. Occasionally they are absent. Again several papules or vesicles may be present in different parts of the body. *In one or two cases which have come to my notice, the vesicular eruption over the skin was most pronounced.* Papules and vesicles with occasional small pustules were thickly scattered over the body. In fact in one of the cases, the eruption and especially *the vesicular eruption was so pronounced*, that *the body looked as if small-pox was present.* An examination of the vesicles, however, showed the presence of plague bacilli. I find that Gotschlich and Zaboltony have found similar cases in which varicelloid like vesicles and pustules were scattered over the whole body, and bacilli could be demonstrated in their serous content.

The question of the occurrence of lymphangitis is a matter of considerable dispute. Its non-occurrence in cases of bubonic plague is believed to be characteristic by many investigators, and special note is made of this fact by the members of the several Plague Commissions, especially by Albrecht and Ghon. The general opinion is that the B. pestis affects an entrance through the skin and travels to certain lymphatic glands by way of the lymphatic vessels. In and around these glands a bubo is developed. In no case, however, is there anything like a lymphangitis, between the point of infection and the site of the bubo.

That such a *mode of infection through the skin is the common one and one which obtains in nature is by no means obvious.* It is usually, in fact almost always *impossible to find any evidence whatever of a point of inoculation through the skin.* Again the bubo is usually developed in and around the lymphatic glands which are not in direct connection with the area of skin through which the infection is supposed to have occurred. The deep and not the superficial lymphatic glands are usually affected, and in groin buboes, the glands situated inside the abdomen, namely, the iliac lymphatic glands, are the most severely affected and form the central core of the bubonic formation. The changes such as hæmorrhagic extravasation into the connective tissue around the glands, and the swelling, œdema, and degeneration of the glands themselves are usually much more pronounced inside the boundary of Poupart's ligament, than more distal, namely, in the inguinal and femoral groups of lymphatic glands.

Again in such cases where a definite point of inoculation was found in the skin, a certain amount of lymphangitis was always present. In the case already detailed, it was present to a marked degree. In others, I have found it equally well pronounced. The exact etiology of this lymphangitis has not been determined. Whether it is the direct result of the B. pestis by itself or due to other micro-organisms, *e.g.*, the streptococcus, acting alone or in conjunction with the plague bacillus, I have found difficult to determine.

The fact that this lymphangitis is present in cases in which a definite point of inoculation is present, makes one sceptical as to the occurrence of infection through the skin. Further details in regard to this question will be given under the pathological section of this research.

It may be as well to mention incidentally at this point, that in the post-mortem room, I have constantly found the B. pestis in the heart blood and spleen in cases of bubonic plague. It is generally acknowledged that during the period immediately before death, the organisms swarm into the blood stream.

In connection with the actual bubonic swellings themselves, it would appear to be of importance to determine what part the B. pestis actually takes in their formation. We have to consider, *whether the B. pestis in pure culture produces the typical pathological lesion, or whether such buboes are the result of the growth of the plague bacillus plus pyogenic bacteria, the latter by their more active growth eventually causing a disappearance of the B. pestis itself.*

Another important type of plague is what is known as *Plague Pneumonia* or *lung pest*. Its occurrence is subject to much variation. It may form the chief variety met with during an epidemic; at other times it is almost entirely absent. Again it may be the type of plague most frequently found at the commencement of an epidemic, or be more or less incidentally met with throughout the whole duration of the epidemic. Its frequency and appearance is therefore subject to considerable variation. The reasons for this, are by no means obvious. This however may be said, that outbreaks of this type of the disease are usually followed by severe and very fatal epidemics, and a good instance of this is found in the well known Black Death, an epidemic in which this type of the disease made felt its utmost severity.

The prevalence of pneumonic plague in Hongkong has fortunately not been marked. It has been met with chiefly in young children.

The point requiring discussion at present is the nature of this pneumonic process. *What constitutes primary and secondary pneumonia?* That the B. pestis is able to set up a condition resembling pneumonia, may be said to be firmly established through the observations of CHILDE and others in Bombay and other parts of India.

In my opinion these pneumonias are either primary or secondary. Primary pneumonic plague is a pathological condition set up in the lungs as a result of direct inhalation of the B. pestis. Secondary pneumonic plague is merely one of the many manifestations of septicaemic plague. In fact buboes and pneumonia may be present together in a septicaemic case of plague.

It would appear that the pneumonias met with in Hongkong are secondary to blood infection. In the cases which occurred during the epidemic of 1903, the blood was examined during the early stages of the disease and plague bacilli were found.

So far as primary plague pneumonia is concerned are we to regard this disease as due to the produce of plague bacilli in the lungs alone, or does a certain degree of blood infection occur at the same time? In the light of most modern bacteriological research, we are bound to admit that in such cases, blood infection does occur.

Reviewing the whole question of plague from a clinical and bacteriological standpoint we are reduced to two main types of the disease, namely:—

1. *Plague septicaemia.*
2. *Primary plague pneumonia.*

In plague septicæmia, bubonic and pneumonic manifestations are frequently met with.

In primary plague pneumonia, these complications rarely if ever occur. This disease, however, is accompanied by a certain amount of blood infection and becomes septicæmic before death.

Primary plague pneumonias are usually fatal. Plague septicæmias are not so lethal.

Considering the question of infection in plague from many points of view, there is much evidence in favour of the following :—

Plague septicæmias are occasioned in the majority of cases by infection through the gastro-intestinal tract. Rarely the infection effects an entry through a breach of continuity of the skin.

Primary plague pneumonias are caused by "drop infection" direct, the B. pestis being inhaled.

On studying various epidemics of plague one is bound to be struck by the prevalence, *during certain outbreaks* of *one particular variety of the disease*. For instance, the pneumonic variety may predominate in one epidemic, the bubonic in another, or epidemics may be met with in which septicæmic cases are most abundant. Again a frequent combination is the predominance of septicæmic cases and cases with bubonic swellings, over pneumonic cases. We have, therefore :—

1. Epidemics of primary pneumonic plague.
2. Epidemics of prevailing septicæmic plague.
3. Epidemics of prevailing septicæmic plague with bubonic enlargements.
4. Mixed plague epidemics.

The factors upon which such outbreaks depend are by no means obvious. One is almost certain, from many points of view, that outbreaks of primary pneumonic plague, depend upon infection with a strain of B. pestis of extremely high virulence. During severe epidemics of primary pneumonic plague we find the plague bacillus fortified to the greatest degree of its pathogenicity.

An explanation of the occurrence of septicæmic plagues with their various complications is difficult to give. Judging from what obtains in the case of the pathogenic actions of other micro-organisms, one is led to believe that the strain of the B. pestis calling forth pure uncomplicated septicæmias is of higher virulence than the strain which not only calls forth a septicæmia but gives rise to complications such as buboes and secondary pneumonias. The higher the virulence of the septicæmia producing micro-organism the quicker is the fatal issue.

Before leaving the subject of pneumonic plague an important point must be mentioned. Plague pneumonia may occur alone, or it may be accompained by the formation of buboes in different parts of the body. There does not appear to be much connection between the occurrence of the pneumonia and the site of the buboes. In connection with this subject Voges reports a most interesting case of plague in which a combination of the different types of the disease was met with at one and the same period of the disease. This case began with pains in the neck, accompanied by redness in the fauces. Plague bacilli are said to have been found in great numbers in the mucus of the throat. For the first three days there was fever with other indefinite prodromata ; then there developed a typical case of plague with buboes, pneumonia and what he calls septicæmia.

This case falls in with the views which I have brought forward. The case was septicæmic and buboes were present. Had buboes been absent, the case would have been an excellent example of septicæmia due to the B. pestis with pneumonia as a complication.

Again the presence of pre-existing disease, *e.g.*, tuberculosis, in the lungs of an individual suffering from septicæmic plague, predisposes towards the occurrence of secondary pneumonia. The plague bacillus finds a more favourable nidus for its development.

These views which I have expressed are original and somewhat in opposition to the general consensus of opinion. I venture to put them forward, in the hope

that other observers will enquire carefully into the subject from the points of view of symptomatology, bateriology and the general factors involved in the question of infection. In the plague bacillus, we have before us an organism which produces pronounced lesions in the body, and these are of a very definite character. These are of the nature of congestions, œ lemas, hæmorrhagic extravasations and the like, into the various organs and tissues of man and animals. Its action may be aptly compared to that of other micro-organisms producing similar diseases in oxen, sheep, swine, etc.

My researches lead me to conclude, in agreement with BITTER, *that the B. pestis is an organism belonging to the septicæmic group of bacteria, the chief powers of which lie in their multiplication in the blood stream, and by so doing, they call forth degenerative changes in the organs and tissues, leading to the occurrence of widespread simple ecchymoses or large blood extravasations.*

WILLIAM HUNTER.

The Relations existing between the Different Types of Plague.

The percentage comparison of the frequency of the different types of plague during the epidemics of 1902 and 1903 is the following :—

Type.	1902.	1903.
Septicæmic,	45%.	37%.
Bubonic,	53%.	58%.
Pneumonic,	2%.	5%.

The relative frequency of the different types of plague at different times during the epidemic may be expressed as follows : —

	1902.			1903.		
	Septicæmic.	*Bubonic.*	*Pneumonic.*	*Septicæmic.*	*Bubonic.*	*Pneumonic.*
January,	...	...	...	2	2	...
February,	...	...	...	16	12	1
March,	1	...	...	63	34	4
April,	3	13	4	74	119	11
May,	20	95	9	102	243	12
June,	74	91	1	39	100	10
July,	70	39	2	22	14	2
August,	34	9	...	9	3	5
September,	1	...	...	3	...	4
October,	1	1	...	4	1	...
November,	...	1	...	4	...	...
December,	...	3	1	1	1	...
	204	252	17	339	529	49

From the course of the 1902 epidemic, the following conclusions are drawn :—

(1.) The epidemic started with septicæmic plague.

(2.) The epidemic finished with septicæmic plague.

(3.) The bubonic variety of the disease was prevalent only during the height of the epidemic.

(4.) The pneumonic variety of plague was most frequent during the middle of the epidemic.

From this table, it is evident that septicæmic plague was most pronounced throughout the whole epidemic. It was only after the establishment of the disease that complications, such as bubonic swellings and secondary lung manifestations became pronounced. Few, if any, cases of primary pneumonic plague were found.

The conclusions to be drawn from the epidemic of 1903, are the following :—

(1.) The epidemic started with septicæmic plague.

(2.) Bubonic plague was also present in equal numbers at the commencement of the epidemic.

(3.) The epidemic finished with septicæmic plague.

(4.) The bubonic variety of the disease only became pronounced at the height of the epidemic.

(5.) The pneumonic variety followed the course of the bubonic type.

From this epidemic, the experience in regard to the prevalence of the different types of the disease, is almost identical with that found during 1902. The start and finish of the epidemic with uncomplicated septicæmic cases of the disease, and the appearance of bubonic swellings and lung complications, during the height of the epidemic, would appear to be of considerable importance in regard to the exact nature of the infection. The course of these epidemics is, in my opinion, additional evidence in favour of the view which I have put forward, namely, *that plague is, ab initio, a disease of a septicæmic nature.*

In both epidemics, septicæmic plague is first in the field, increases proportionately during the course of the epidemic, and closes up the rear. The bubonic and pneumonic manifestations are met with in considerable numbers, only after the establishment of uncomplicated cases of plague septicæmia.

Sex Incidence in Plague.

Both sexes would appear to be equally affected.

Age Incidence in Plague.

The disease is most frequently found between the ages of 20 and 40.

Infants and children would appear to suffer more frequently from plague, than is generally supposed. According to Lowson, Aoyama, and others, infantile plague is rare. My results show that during plague epidemics, the disease figures largely as a cause of death in children under 5 years of age.

The following figures may be of interest, representing the results obtained after performing 812 post-mortem examinations on children under 5 years of age:—

	Under 2 years.	*Over 2 years and under 5 years of age.*
Septicæmic Plague.	31	50
Bubonic Plague, ...	4	27
Pneumonic Plague, ...	4	14
	39	91

These figures permit of the following conclusions:—

(1.) Children under two years of age, most frequently contract plague in the uncomplicated septicæmic form.

(2.) The bubonic and pneumonic varieties of the disease are rare in children under 2 years of age.

(3.) All types of plague are more frequent in children over two and under five years of age.

(4.) Lung forms of plague are more common in children over 2 and under five years of age. In fact my figures show that over 40% of the total number of pneumonic varieties of plague, occurred in childen under five years of age.

Occupation Incidence in Plague.

In past epidemics, it has been extremely difficult to obtain any accurate information in regard to this subject. The "dumping" of dead bodies has a great deal to do with this difficulty.

It is known that medical men, nurses, attendants on plague patients, and members of different plague staffs, rarely contract the disease.

Coolies, cooks, hawkers, married women, mill workers, and domestic servants account for a large number of the cases.

So far, however, little can be said in regard to occupation incidence. The Indian Plague Commission of 1901 came to the conclusion, *that the incidence of plague is not dependent on trade or occupation.*

WILLIAM HUNTER.

Pathological Anatomy.

During the past two years, nearly 1,500 post-mortem examinations have been held upon plague corpses. In almost every case, the body was thoroughly examined for lesions due to the action of the B. pestis. By this routine method, a number of interesting facts regarding the pathology of plague has been ascertained. All types of the disease have been examined; a goodly number of children were also dissected and the lesions in them compared with those met with in adults. Many of the females examined were pregnant, others had aborted just before death. In such cases, the contents of the uterus was inspected for the presence of characteristic plague lesions.

In the majority of cases, a history of the cases brought for post-mortem examination was not ascertainable. This was due to the fact that most of the bodies were found, either in deserted houses, streets, the harbour, or the hill sides. Most plague bodies show a considerable amount of bluish discolouration. This develops to its greatest degree from 6 to 12 hours after death. It is well marked on all dependent parts, but occasionally is found more or less all over the body, and especially on the face, scalp, neck and shoulders. This discolouration of the skin is a marked condition in plague, and in plague infected areas; such an appearance of a body ought to raise suspicion as to the existence of the disease. The appearance is by no means confined to plague. It may be met with in malaria, beri-beri, etc., but is never so pronounced. It is one of the signs relied upon by the advocates of simple corpse inspection and is of use to those who are engaged in superficially examining cases of uncertified death, and who have in many instances to give what must be regarded from a professional point of view an unscientific opinion. *The determination of the cause of death by such corpse inspection is in many cases directly opposed to the principles and practice of medicine.* The only thing which can be allowed for corpse inspection, is the hint occasionally given by such a "viewing of the body" as to the advisability of ordering a necropsy in order to place the diagnosis of plague upon an irrefutable positive or negative basis. In Western countries, corpse inspection ought to be completely supplanted by post-mortem examination. In the Orient, on the other hand, a certain amount of licence must be allowed in medicine owing to native prejudice.

Rigor mortis does not set in early in plague. In may be completely absent.

The majority of cases of plague occur in well nourished individuals. Emaciation is not a characteristic post-mortem appearance. Opinions appear to vary as to the rate of decomposition of plague corpses. WILM notes in his Report that "there was no marked tendency to decomposition." This is not my experience. Changes rapidly set in amongst the abdominal viscera, and the body quickly becomes discoloured. A good deal, however, depends upon the time of the year when the necropsy is performed. During the hotter seasons in Hongkong, post-mortems on plague bodies have to be held within 12 hours, if reliable results are to be obtained in regard to the pathological appearances of the organs and tissues. Other factors of importance are the conditions of the body as to nourishment, fat, etc., the age of the individual, the presence of certain micro-organisms which produce rapid putrefaction. The condition known as "foaming organs" is one which I have found frequently at the Public Mortuary. This condition is caused by the Bacillus aerogenes capsulatus of WELCH. During the hot seasons of the year, this organism plays great havoc with much of the interesting pathological material at the Mortuary. So rapid is its effects on the organs and tissues, that the delay of 6 to 10 hours in performing the autopsy may render a correct diagnosis almost impossible. I have known of bodies, still warm, having been brought to the Public Mortuary from the Tung Wah Hospital for examination at 10 a.m. and by 5 p.m. the corpse was

blown up, putrefactively discoloured, and unfit for dissection. This being so, it is now my practice during plague epidemics to have all bodies, which are in the Mortuary at 5 p.m., examined before finishing the day's work.

The skin is normal in some cases. Eruptions may be present or absent. On close inspection a few small petechiæ are usually found. These are most frequently met with about the groin and anus, the axillæ, the mucous membranes of the mouth, pharynx, nose, the conjunctiva. Plague bacilli have been isolated from such petechiæ, showing their origin to be due to a local growth of the causal agent.

On the other hand, one frequently comes across spots of quite a different origin. These are usually bright red in colour. They vary in size from a pin's head to a pea. Considerable numbers of these may be present. The whole body may be covered with them. Usually, however, the exposed parts of the skin show them in greatest profusion. The face, neck, anus, hands, legs and feet are "spotted." These spots would appear to have nothing to do with the disease directly. Like most observers, I am of opinion, that they are due to the bites of insects, *e.g.*, flies. In plague, a general degeneration of the tissues takes place, and the virus actively produces extreme degeneration of the endothelial lining of the blood vessels. The capillary walls therefore are in a degenerated condition, accounting for the occurrence of haemorrhages. With such a condition as this present, the bites of insects, slight blows, punctures made by needles, etc., are much more liable to leave their mark by the occurrence of slight or more or less extensive haemorrhage into the skin and adjacent connective tissue.

In addition to those already mentioned one frequently comes across cases presenting definite skin lesions. These are of a varying nature, papules, vesicles and pustules are met with together in the same case. These pustules may be large in size and resemble boils or carbuncles. These eruptions are found in all the so-called different types of plague. The vesicular and pustular forms of skin lesion are most frequently present.

In one case which was examined post-mortem, an extensive vesicular eruption was scattered over the body. A few papules were also present. Some of the vesicles had already developed into pustules. There was no eruption on the palms of the hand or soles of the feet. The eruption was most extensively found on the extensor aspects of the extremities. On superficial examination, the case was thought to be small-pox. A bubo was present in the right groin, containing numerous plague bacilli. Numerous plague bacilli were found in many of the vesicles. *For details of this case, vide Case No. I.*

In other two cases, the point of inoculation was found, and extending from this, there was slight lymphangitis. Along the course of the latter, secondary vesicles had developed. A bubo was found in the axilla. *Vide Cases Nos. II and III.*

True carbuncles and boils have not been found. They are simply exaggerated pustules. I am in agreement with Lowson who denies the existence of these lesions in plague. They may occur during convalescence as a result of the debilitated condition of the patient. If they do, they have no connection with plague, but are set up by infection with ordinary pyogenic bacteria.

On cutting open a plague corpse, the first thing which strikes the eye, is the congestion of the subcutaneous tissues. If the body be still warm, blood will be found to well out from the numerous arterioles and capillaries. The tissues themselves have a bluish appearance, and on closer examination, a perfect net work of engorged capillaries can be seen. Such an appearance is general over the whole body. Extravasations of blood, small and large, are also found in the subcutaneous connective tissue. In one case a very diffuse haemorrhagic extravasation was found extending over the lower half of the anterior abdominal wall. *Vide Case No. IV.* On dissecting the muscles, one finds evidence of marked degeneration in these tissues. The colour of the muscles is changed to a greyish yellow, they have a dull lustre. Teased muscle preparations show the presence of granular degeneration. In other cases, there is marked fatty degeneration as evidenced by the reactions obtained with oxalic acid and Sudan III.

A description of bubonic swellings, their origin, nature, and an interpretation of their formation, is reserved for a special chapter. On exposing the thoracic cavity and throwing back the sternum with its costal attachments, another point strikes one, namely, the presence of marked capillary congestion around the ribs and costal cartilages, especially on their inner surfaces. Again the post-sternal connective tissue shows a perfect network of injected blood vessels. Occasionally diffuse hæmorrhages are found occupying the spaces of this areolar tissue.

The pericardial sac is of a reddish blue colour. The parietal layer is studded with engorged vessels ramifying in all directions. In the majority of cases, apart from the presence of hæmorrhage of varying size, the pericardium is normal. Rarely, however, inflammation of the sac is found. Two such cases have come under my notice. In both acute pericarditis was present. The inflammation was hæmorrhagic in type. Plague bacilli were found in the fluid, along with pneumococci and streptococci. *Vide Cases V and VI.* The presence of this condition of hæmorrhagic pericarditis in plague is, I believe, very rare, such an inflammation is more commonly met with in tubercular and malignant disease or in cases where there is extreme cachexia.

The visceral pericardium resembled the parietal layer. Hæmorrhages were more frequent, especially over the posterior surfaces of the heart, along the coronary vessels, over the auricles, and about the entrances of the pulmonary veins. Sometimes large crops of such petechiæ would be found. The pericardial sac always contained a small quantity of serous fluid, which was almost always blood stained.

The actual state of the heart varies. In some cases the whole organ is flabby, with little evidence of post-mortem muscular contraction. In others the left ventricle is found firmly contracted with a flabby and dilated condition of the right sided cavity. In a few cases in which plague complicated beri-beri, the heart was of enormous size. It was what one might term a "Bullock's Heart." Large hearts are well known in beri-beri.

On opening the heart, it is usually found to contain a large quantity of dark, thick, non-coagulated blood. This blood does not tend to coagulate after its withdrawal from the body. This probably depends upon the admixture of the blood with the poisons elaborated by the specific virus.

Ante-mortem blood clots are frequently found, especially on the right side of the heart.

The endocardium is frequently normal in appearance excepting the presence of small hæmorrhages. These are mostly found in the ventricles, and about the valvular openings. These petechiæ are found as frequently on the left as on the right side of the heart.

Valvular lesions were sometimes met with. In all probability they had nothing to do with the disease.

The myocardium was always found in a condition of degeneration. It was frequently congested with cloudy areas of degeneration, scattered throughout its substance. In other cases the musculature was brownish red in colour and dry. Punctiform petechiæ are often found between the muscular fibres. Actual myocarditis has never been found. In general, the venous circulation was found in a condition of engorgement. Small petechiæ were frequently found on the inner walls of the arteries and veins.

In all cases of plague, more or less extensive circulatory disturbances are found about the pharynx, larynx, trachea and œsophagus.

The pharynx is often hyperæmic and œdematous. Likewise the tonsils often show great swelling, and on section, occasional hæmorrhages are found in the lymphoid tissue. In certain cases the changes in the tonsils resemble that found in an ordinary bubo. Extravasation of blood, œdema, inflammation, and necroses may be found present. Plague bacilli are found in great numbers in such tonsils. These cases lead one to believe that, in certain instances, the virus may gain an entrance to the blood stream through this channel.

The epiglottis usually hyperæmic and œdematous. The mucous membrane of the entire larynx, is found in a similar condition. The submucous connective tissue is usually œdematous, and such continues from the larynx upwards to the pharynx and again to the capsule of the thyroid gland. The trachea and bronch are also found congested, and on the mucous membrane, a thick, greyish yellow secretion is found. This is often blood stained.

Plague bacilli can frequently be found in the secretion present on the mucous membrane. The smaller bronchi and bronchioles are usually much congested and œdematous. The pleural cavities frequently contain a small quantity of serous fluid. It may be blood stained. The pleura itself is usually in a condition of congestion, and petechiæ are almost always present in varying number.

The lungs, on opening the chest only partially collapse. They are usually vesicular throughout. On section, they are found congested, and dark, thick, tarry looking blood wells out of the cut ends of the pulmonary vessels. Œdema of the lung tissue is frequently found. In cases associated with beri-beri this œdema is extreme, and on section, there flows from the cut surfaces a considerable amount of frothy, red serous fluid. The posterior parts of the lung tissue, is more solid and frequently sinks when placed in water. The condition is not pneumonia, but simply to the gravitation of blood to the most dependent parts of the organ.

Occasionally one finds small areas of hæmorrhage scattered throughout the lung tissue. These can be seen previous to section of the organ. Many look like pulmonary apoplexy. Infarctions are also found. In plague, the occurrence of metastases in the lungs is common. Although plague pneumonia in its various forms is discussed freely, yet it is difficult even at the present day to find a clear account of the exact pathological processes at work in the production of such a condition. Mention is made in various treatises dealing with plague as to the presence of consolidated areas in the lung. These may be lobar or lobular. Pleurisy accompanies the process. The symptoms during life are those of pneumonia and enormous hoards of plague bacilli are found in the sputum.

In discussing the presence and mode of formation of pneumonic areas in the lungs in plague, we have to determine the following: The type or types of pneumonia present, the distribution of the areas of consolidation in the lungs, the histological appearances of such consolidated areas, the part played by the plague bacillus in the production of the pneumonia, and the possibility of the origin of such a process being accelerated through the presence of other micro-organisations. These and other factors must be considered in regard to plague pneumonia.

So far as my experience goes, I believe that *there exists two main forms of consolidation of lung tissue in plague.*

One of these is undoubtedly a pneumonic process, namely, *primary pneumonic plague. The second is a form of patchy consolidation occurring as a complication of ordinary septicæmic plague.*

In the former the virus reaches the lung by way of the respiratory tract. In the latter, the infection is through the blood.

Primary pneumonic plague is comparable to an influenzal pneumonia. The B. pestis takes the same share in the production of this pneumonic plague, as the B. influenzæ takes in the production of influenza pneumonia. Both these pneumonias are extremely fatal, primary plague pneumonia being especially so. Primary plague pneumonia usually is lobar in distribution. It may be occasionally lobular. The consolidation is complete, accompanied by lesions of the overlying pleura and the production of large quantities of fibrin, in the meshes of which enormous collections of red blood corpuscles are found, the condition is virtually a hæmorrhage into the alveoli of a lobe or lobule of the lung. The intensity of the alveolar changes are much greater than ever seen in pneumonia due to the pneumococcus. So great are these changes produced by the growth of the B. pestis in the alveoli, that a recovery is, in almost all cases, not to be entertained.

This form of plague pneumonia is not common in Hongkong.

The part played by other micro-organisms in its production is difficult to determine. Pneumococci and streptococci are almost always present with the B. pestis in the sputum. The subject of mixed infection and its action on the

lung tissue is a difficult subject and so far an extremely unsatisfactory one. In primary plague pneumonia, the B. pestis may be found in the blood stream. The condition is not septicæmia. There is no evidence of the multiplication of the organism. Before death, on the other hand, similar to what occurs in other diseases, the blood swarms with the causal agents of the disease. Primary plague pneumonia would appear therefore to be something entirely different to the other form, presently to be described. In my opinion, it is the only true form of pneumonia (strictu sensu) found in plague. All other consolidations of lung tissue occurring during an attack of plague do not appear from my investigations to be pneumonias as we at present understand, but of a very different nature.

The second type of pneumonia, or what would better be termed, areas of consolidated lung tissue, would appear to be distinct from primary pneumonic plague. In fact my own researches seem to show, that such areas of consolidation are in reality not areas of pneumonia. The type of pathological change met with is not comparable to true pneumonia It is not definitely acutely fibrinous, or acutely catarrhal in type and would not appear to pass through the definite series of changes usually found in the now well recognised pneumonic diseases of the lung. The areas of consolidated lung tissue in this second type, are usually multiple. Rarely they are single in the lung. They vary in size and distribution. Neither a lobular or lobar distribution is met with. They occur erratically. They occur as frequently subpleural as in the central lung tissue. The solid areas appear largely composed of extravasated blood in and around portions of the lung. Indefinite numbers of alveoli are included in the mass. There is not much evidence of participation of the actual cells, wall of the alveoli, and included connective tissue in the production of the lesion. The areas appear to increase in size by peripheral extension of the hæmorrhagic infiltration. The more centrally situated areas apparently undergo necrosis.

I am inclined to the opinion that these so called secondary pneumonias, or the areas of consolidation of the lung, are in reality instances of what is known as *pulmonary apoplexy or infarction.* This is all the more likely when we remember that the action of the plague virus is severe on the circulatory apparatus inducing degeneration of the vessel walls, with the occurrence of multiple hæmorrhagic extravasations.

This form of pest pneumonia, as it is called, is the result of blood infection. My researches in regard to this point are in accordance with those of WILM and the conceptions of GAFFKY.

In support of the foregoing, the occurrence of infective emboli with the production of metastaxis is well known in plague.

In such cases plague bacilli are present in hoards in the sputum.

It may be difficult in the absence of any definite previous history of the patient to say clinically, what particular type of consolidation is present.

Such areas of consolidation in the lung, account for many cases returned as plague pneumonia. It may set in during the early stages of the disease and be regarded as true pneumonic plague. Clinically, therefore a diagnosis between primary pneumonic plague and these consolidated areas in the lung, may be almost impossible. Post-mortem, however, the anatomical relations of the pathological process determine the exact nature of the disease.

Such cases of so called pneumonia as a type of septicæmic plague, would not appear to be so lethal as cases of primary pneumonic plague.

The bronchial glands are occasionally enlarged. Petechiæ may be found present. The mediastinal glands show practically the same. Both series are usually deeply pigmented. Œdema is another factor common to both. In one case in which multiple buboes were present, a distinct bubonic like mass was found in and around the superior mediastinal lymphatic glands. *Vide Case No. VII.*

Lastly the thymus gland in children is often much enlarged and congested. Petechiæ may be found scattered throughout its substance. The normal milky fluid of the organ is much increased in amount, and must not be mistaken for pus which it resembles.

The condition of affairs met with in the alimentary canal in plague has been the subject of considerable dispute. Some observers state definitely that the digestive tract in this disease presents nothing of any great pathological importance. Other investigators, however, attach considerable weight to the presence of certain alimentary lesions, regard the changes present as more or less constant, but beyond this see no reason to ascribe to this system more than its participation as well as other organs in the series of general pathological phenomena of plague.

Few, if any, plague experts have brought the gastro-intestinal tract into relationship with the avenue of plague infection. The general consensus of opinion is against food infection and food conveyance as factors of importance in the spread of the disease. The weight attached to the inoculation method of infection has more or less swamped other possible channels of conveyance of the disease, so that the latter have almost entirely been disregarded by those supposed to be measuring out careful and well grounded scientific principles and prophylaxis of plague. WILM is almost the only observer who has brought forward the view that the alimentary canal is an important channel through which plague infection occurs. The evidence which he adduces is strongly in favour of such a mode of infection. Little importance seems to have been attached to the results which he obtained, results which are still considered by sientific congresses to be of great value, and requiring confirmation.

After a careful perusal of the results obtained by the various Plague Commissions, amongst which one finds ample evidence of considerable pathological change in the alimentary canal, it is surprising that so little weight has been attached to these. My own results, coupled with the careful consideration of the clinical aspect of plague as well as the result of experimental research, *e.g.*, insect spread of the disease, infected food, etc., have led me to the belief that from the point of view of plague prophylaxis the gastro-intestinal tract and what is administered to it, are of the highest importance.

The alimentary canal shows more or less always definite evidence of pathological change. In some cases, the lesions present may be slight, but in others, they are severe. In another part of this research, it has been shown, that symptoms such as diarrhœa and vomiting, referrable to some morbid condition of the gastro-intestinal tract, are present during the initial stages of all varieties of plague septicæmia. These may be present only during the early part of the disease, but frequently one finds a persistence of some alimentary symptom, particularly a continuance of diarrhœa.

The following is a brief account of the results of my post-mortem examinations.

The mucous membrane of the mouth and pharynx is conjested, and frequently petechiæ are present. The condition of the tongue has already been given (*Vide* Symptoms).

The œsophagus is usually hyperæmic. Œdema is also a frequent manifestation, and is often accompanied by scattered hæmorrhagic extravasations. The latter are most numerous near the opening of the tube into the stomach. The cardiac end of the œsophagus is frequently surrounded with blood extravasation.

The stomach is usually hyperdemic, and petechiæ are scattered more or less generally throughout its walls. Œdema is frequent. The congestion and hæmorrhages are especially well marked about the apices of the folds of the mucous membrane.

All the changes found in the stomach, are usually most severe, at the cardiac end, the lesser curvature, and the pyloric aperture. Hæmorrhages of considerable size are occasionally found. Some of these may be present in the fundus, as large as a dollar piece.

The vessels in the stomach wall, and particularly the veins are usually found distended with blood.

Ulceration has also been found. It is rare however. The ulcers, if found, are small in size, varying from a pin's head to a pea, and arise in connection with foci of hæmorrhage. This condition is quite uncommon, and much of the ulcerated appearance is, on closer examination, produced by post-mortem digestion, the results of which are apt to lead one astray.

The appearance of the stomach in cases of plague has been admirably given by Captain James, I. M. S., in a Report on Plague, published in 1897. I agree with the statements made, that in certain cases, the appearance of the mucous membrane of this viscus may approach that of the rash seen on the skin in a severe case of purpura.

The condition of the small intestine is similar to that found in the stomach. The changes met with are more severe. Œdema of certain parts is extreme, and petechial hæmorrhages are also found, particularly about the ileum. These are formed in connection with blood extravasations. They vary much in size. They are irregular in shape and apparently occasionally coalesce. They do not penetrate deeply. The early stages of these ulcers are represented by small areas of necroses in the mucous membrane. Such seem to slough and leave an excavated surface.

In many cases the areas of necrotic mucous membrane, which may be pin head in size, may be present without actual ulceration.

Again other cases are met with in which there is nothing present beyond extreme hyperæmia and numerous petechiæ.

Pyer's patches and the solitary follicles also participate in the changes. These elements are swollen and may be hæmorrhagic. In the region of Bauhini's valve the intestinal changes are usually most marked. The solitary follicles are swollen, look like granules of sago, with a deeply pigmented centre.

Apart from the condition of the mucous membrane the appearance of the peritoneal surface of the intestines is that of hyperæmia. The colour varies from a bright red to a dark reddish blue.

The various coats of the intestine are thickened, soft, and often œdematous. Beautifully marked capillary injection is seen through the peritoneal lining, passing towards the mesentery.

The contents of the intestine are soft and bile stained. They are very tenacious, and stick firmly to the mucous membrane. They may be blood stained and tarry looking. The microscopical examination of several parts of the small intestine has been undertaken. There is evidence of inflammatory change extending through the wall of the gut.

The condition of the cœcum resembles that of the ileum.

In the large intestine the changes are less severe, occasionally large flat subserrous hæmorrhages are found.

The liver is increased in size and weight. Its consistence is firm and capsule is stretched and shows the congested parenchyma shining through it. Hæmorrhages are occasionally met with in the capsule. On section the organ drips with blood. The general colour of the cut surface is dark red, and frequently after thorough washing, small greyish-white areas can be seen. These are soft, and never much larger than a pea. Occasionally they are hæmorrhagic. Extravasations of blood, small and large, may be found scattered about the organ. These grey foci have been examined microscopically. These areas are found chiefly in the portal vein zone of the lobule. They are composed of necrotic tissue and in many cases, bacilli, identical with plague bacilli, were found lying in the debris. That plague bacilli are actually found in the situations has been accurately determined by cultural methods. The condition resembles that found in the liver in cases of enteric fever. Hæmorrhages may be found in the coronary ligament.

The gall bladder is usually distended with bile. The walls are thickened, soft, and œdematous and small blood extravasations are seen shining through the wall. The bile is thick and very tenacious. Plague bacilli have been isolated in pure culture from this viscus.

The spleen is almost always congested. On section blood flows freely from the cut surfaces. Plague bacilli are demonstrable in all cases. Little can be said as regards the size and general structure of the organ, owing to the almost constant presence of changes referrable to other causes, *e.g.*, malaria, beri-beri, etc. In what may be regarded as spleens of normal size, the pulp is soft. The follicles are usually plainly marked. Hæmorrhages of ranging size are often found beneath the capsule and into the parenchyma. Infarcted areas have also been seen. The parenchyma

decomposes rapidly. The kidneys are increased in size and weight. The capsule is tense. It can be easily detached. Marked capillary injection is seen shining through the capsule. The cut surface is dark red in colour. The hyperæmia is most marked in the medullary portion. A condition of acute parenchymatous nephritis is frequently present. The pelvic mucous membrane shows marked capillary congestion and may show a few petechiæ. The ureters are thickened and often œdematous. Petechiæ are found in the mucous membrane. The bladder, apart from the presence of a few hæmorrhages, may be normal. In other cases the mucous membrane is hyperæmic.

The suprarenals are congested, but otherwise normal. The male genital organs are normal. Hyperæmia and petechiæ are found frequently in the testicles. In buboes situated about the groin, the hæmorrhagic extravasation may extend along the vas deferens to the epididymis and testicles. The scrotal connective tissue may also be infiltrated with extravasated blood.

The female genital organs vary in appearance and in the extent of pathological change. The appearance presented by the peritoneal surfaces of the organs is one of congestion with hæmorrhagic extravasation. Hæmorrhages between the layers of the broad ligament are common. The ovaries are congested. The graafian follicles frequently contain extravasated blood. Petechiæ are found on the surface of the body of the uterus. The endometrium is congested, with frequent epithelial degeneration and hæmorrhages. Petechiæ may also be found in the vaginal wall. The vulva may be the seat of a dense infiltration of extravasated blood, the condition being an extension of the condition found in a neighbouring groin bubo.

The urine is albuminous. It contains usually varying amounts of blood. Its specific gravity is low. The chlorides are diminished. Indican is usually present, and in the sediment, leucocytes, red blood corpuscles and various varieties of casts are found. The B. pestis is frequently to be found in the urine.

The pancreas is congested. Hæmorrhagic extravasations are frequent about the head of the organ. This organ rapidly decomposes in cases of plague. The peritoneum is usually moist and shiny. The cavity contains a variable amount of yellow and turbid serum. Small petechiæ may also be present. In many cases in which bubonic-like swellings are present in the mesentery and in the external iliac lymphatic gland region. The retroperitoneal glands, the ductus lymphaticus with the cystema chyli are embedded in a soft hæmorrhagic mass. This infiltration extends in all directions, but is specially upwards to the portal vein and to the capsule of the kidneys. Further details in regard to these intra-abdominal extensions of bubonic swellings will be given under the subject of Buboes. The mesentery is a frequent site for the presence of hæmorrhages. These are often very extensive. In one or two cases, almost the entire mesentery was extravasated with blood. The folds of the mesentery are also soft, and œdematous. The contained lymphatic glands are enlarged and hæmorrhagic. The lymphatic glands standing in relation to the ileum and coecum are always most affected. These are frequently double their ordinary size and on section are œdematous with minute blood extravasations into their parenchyma.

The glands may be embedded in a hard, thickened mass of hæmorrhagic and present on section areas of hæmorrhage, necrosis, etc. These are typical bubonic formations. Several cases of this bubonic formation have been found. *Vide Cases Nos. VIII, XI, X.* The ordinary pathological appearances of the mesentery in cases of plague are fully described by Wilm. My own results are more or less in harmony.

The central nervous system is generally very congested. Hæmorrhages are present throughout. In a considerable number of cases of plague in females, abortion had occurred. The fœtus and placenta was examined in every case. Plague bacilli have been found in the placenta, but never in the umbelical cord or fœtus. The tissues of the latter are similary affected. Hæmorrhages are frequent. The placenta appears to present an absolute barrier to the B. pestis. The poisons produced by the organism, however, are conveyed to the fœtus, calling forth in the organs of the latter, pathological changes similar to those found in ordinary cases of pest.

The pathological changes found in plague may be summed up as follows :—

1. General congestion and hyperæmia.
2. Widespread haemorrhagic extravasation.
3. Marked glandular enlargement, œdema and haemorrhage.
4. General granular degeneration of all organs and tissues.

I know of no other infective disease in man with pathological features like plague. In animals, various septic diseases produce almost identical post-mortem appearances. The pathological appearances of the tissues of persons who have succumbed to the venom of certain species of snakes, resemble somewhat those met with in plague.

Case No. I.—An adult male Chinese, æt. 25, brought to the Public Mortuary for examination. The body was found in a deserted house. The corpse was that of a well nourished man. The skin had the cyanosed appearance met with in plague. On superficial examination, *the case looked like one of small-pox*, vesicles and pustules being scattered over the face, shoulders, anus, body, and legs. It is not my custom to perform a necropsy on the majority of small-pox cases. They are merely examined superficially in order to determine the diagnosis. On this particular occasion, I remember that the Caretaker of the Mortuary, who has had a large experience in this line, pointed the case out to me as one of small-pox. An eruption covered the skin. Papules, vesicles, and pustules were present side by side. They were numerous over the neck, back, shoulders, back of arms, ventral surface of the abdomen, the extensor surfaces of the thigh and the buttocks.

The papules were fewest in number. They were small, never larger than a pea, raised above the general surface of the skin, and surrounded by extravasated blood.

The vesicles varied in size, they were occasionally umbelicated, apparently ran together, contained turbid serum containing a few plague bacilli and were also surrounded by a discoloured area of skin due to blood extravasation. The pustules were the most numerous. They also varied much in size. One was present on the shoulder which resembled an ordinary boil. Their bacteriological contents were subject to considerable variation. Plague bacilli were found in what appeared to be the most recently formed pustules. In others, which were evidently more advanced, no plague bacilli were found, ordinary pyogenic micro-organisms being present. There was no question of small-pox.

A bubo was present in the right groin, which contained plague bacilli.

Plague bacilli were also found in the heart blood and spleen.

This case was interesting from several points of view, namely :—

1. The bubonic nature of the case.
2. The presence of a generalised skin eruption
3. The nature of the eruption being papular, vesicular, and pustular.
4. The presence of the B. pestis in the erupted foci.
5. The absence of any apparent lymphatic connection between the eruption and the bubo.
6. The likeness presented by the case to small-pox.

Case No. II.—A Chinese male, æt. about 28, a coolie engaged in a godown. Post-mortem, the general appearances were those of septicæmic plague. The B. pestis was found in the heart blood and spleen. A well developed bubonic swelling was present in the right axilla. It contained hoards of the virus. Passing from this peripherally, one found rows of small vesicles, at first along the inner side of the arm, then along the supinator longus muscle area to the wrist where they apparently ended.

No evidence was found about the hand of injury to the skin. Plague bacilli and streptococci were found in the vesicles.

This was probably a case of direct infection through the skin. Lymphangitis could not be seen. The case was not examined clinically.

Case No. III.—A Chinese female, æt. about 20. This case was seen during life. A bubo was present in the right axilla. No definite point of skin inoculation was discoverable but extending from the wrist to the elbow, on the flevor and extensor aspects of the forearm, numerous vesicles and pustules were found. Plague bacilli were found in many of the vesicles. The examination of the pustular contents gave negative results so far as plague bacilli are concerned. Lymphangitis was present in the forearm and arm, particularly along the latter.

Plague bacilli were found in the blood and bubo. The case was not examined by me post-mortem.

Case No. IV.—For particulars in regard to this case, reference must be made to Case No. II under the heading of "Buboes and their Significance."

Case No. V.—A Chinese male child, aged about 10 years. The general post mortem appearances were those usually found in plague. The B. pestis was found in the heart blood and spleen. The type of disease was septicæmic. There was no trace of a bubonic swelling. The pericardial sac to external appearance was reddened and congested. On section the parietal layer was much thickened, œdematous and extremely vascular. The sac was full of thick blood coloured fluid containing numerous solid particles which had the appearance of fibrin. Plague bacilli were found in this fluid. Other micro-organisms were present, particularly pneumococci. The inner surface of the parietal layer was rough and irregular, due to the deposition of a slight amount of fibrin. The type of inflammation was hæmorrhagic, and numerous extravasations of blood were found in the wall of the sac. The visceral layer was also thickened, particularly in patches. Patchy hæmorrhagic extravasations as well as numerous minute petechiæ were found in this layer. The latter were especially well marked at the point on the heart's surface marking the interval between the auricles and ventricles, and along the course of the coronary vessels. The lungs were healthy, although very hyperæmic. The mediastinal glands were enlarged and showed cortical blood extravasation. There was no periglandular effusion of blood.

Case No. VI.—A Chinese male adult, aged about 30. Typical post mortem appearances were found. Plague bacilli were present in abundance. A bubo was present in the right axilla. The pericardium was in a condition resembling more or less that found in Case No. V. There was much more fibrin formation. Plague bacilli could not be demonstrated with certainty in the pericardial fluid. Microscopically organisms resembling the B. pestis were found, but the results of cultural experiment were negative. The organism present in greatest abundance was the pneumococcus. The mediastinal glands were enlarged and extremely hyperæmic. There was no apparent extravasation of blood. In the lungs, patchy consolidation was found, and plague bacilli were numerous.

Case No. VII.—For particulars in regard to this case, *vide* Case No. I under "Buboes and their Significance." The lymphatic glands were enlarged, œdematous and hæmorrhagic. They were embedded in extravasated blood, the latter extending into the posterior mediastinum, and upwards to the cervical lymphatics at the roof of the neck. Plague bacilli were present in enormous numbers in the mass.

Case No. VIII.—A Chinese male child, aged about 12. The general post-mortem appearances were those of septicæmic plague. The lymphatic glands corresponding to ileum of the small intestine were enlarged, and hæmorrhagic. They were embeded, in a mass of hæmorrhage. Plague bacilli were present in masses. The other glands of the mesentery were free, but enlarged, very œdematous and hæmorrhagic. The glands about the coeliac plexus were also enlarged and hæmorrhagic. The ileum was hyperæmic, and "spotted" with petechiæ. Its mucous membrane was studded with infiltrated solitary follicles around many of which was a zone of hæmorrhage. There was no ulceration of the mucous membrane. Peyer's patches were apparently unaffected. The remaining portions of the small intestine were normal to the unaided eye. The large intestine and rectum was normal.

Case No. IX.—For details, *vide* Case No. I under "Buboes and their Significance." In this case the stomach, and the small intestine in general were hyperæmic. Petechiæ were most numerous about the walls of the stomach, duodenum and ileum. There was streaky ulceration of the mucous membrane of

the stomach. This was distinct from post-mortem change. No denudation of the mucous membrane of the small intestine was found. In other respects the appearance of the case resembled that found in Case No. VIII.

Case No. X.—For details, *vide* Case No. VI. under "Buboes and their Significance."

WILLIAM HUNTER.

Pathological Conditions complicating Plague.

During the past two years, nearly 1,500 post-mortem examinations were held, and in addition to the lesions produced by the plague virus, other pathological conditions were occasionally met with, some of which are of great interest. Among the pathological conditions found in plague corpses, may be mentioned :—

Beri-beri, ...common.
Malaria, ... ,,
Dysentery, ...rare.
Alcoholism, ... ,,
Marasmus, ...common.
Tuberculosis, ... ,,
Heart Lesions, ... ,,
Enteritic conditions, etc..... ,,
Abortion, ... ,,

A case of *Plague Meningitis* was found last year. The dura was intensely congested and on section dripped with blood. The pia mater and grey matter were very hyperæmic and small haemorrhage had occurred. The convolutions were flattened the hemispheres œdematous, and the ventricles were distended with blood coloured serous fluid. Plague bacilli were abundant in the ventricles and on the surface of the cerebral hemispheres. This case occurred in a female child aged about 10.

Two cases of what might be called *Plague Apoplexy* came under my notice. Both occurred in adult males suffering from septicæmic plague. Hæmorrhage into the internal capsule was found in both cases.

In regard to the presence of other micro-organisms in plague, which are actively producing lesions, those which I have most frequently found are :—

(1.) Streptococcus pyogenes —producing intense streptococcic septicæmia.
(2.) Streptococcus lanceolatus—frequently producing pneumonia.
(3.) Staphylococcus pyogenes.—This organism is almost always present in buboes. It is rarely found in the blood stream.
(4.) The bacterium coli commune—occasionally found.

Amongst the extemely rare pathological complications which I have found in plague corpses are :—

Gangrene of the lung.
Gangrene of the tonsil.
Fracture of the skull, } both the result injury.
Rupture of the spleen, }

WILLIAM HUNTER.

Buboes and their Significance.

The occurrence of swellings in certain regions of the body is one of the commonest accompaniments of plague. The term "bubo" has been used so frequently and loosely in connection with plague that the disease has generally become known, amongst the laity at least, as "Bubonic Plague." Why such an adjective should be constantly prefixed to the actual name of the disease is not clear and most certainly not based upon accurate scientific information. The

presence of buboes is one of the most constant and at the same time one of the characteristic phenomena of certain types of the disease, yet when we review the whole history of plague as a dreadful "pest," it is found that so-called bubonic plague is by no means the most horrible manifestation of the disease, and never occasions such devastation of life as other prominent forms of disease, such as primary pneumonic plague. In fact, one might go so far as to describe ordinary bubonic plague as more the benign type of plague, the malignant type being represented by primary pneumonic plague.

Much has been written in regard to these bubonic swellings, and from the voluminous literature on the subject, one would conclude that almost the last word had been spoken in regard to this pathological lesion. Taking up the question from the standpoint of our present day conceptions of bubonic plague, however, there would appear to be still many points wanting, to complete the chapter dealing with such manifestations of plague, and the true interpretation of their presence.

For the past two years, I have had considerable insight to the presence of buboes, and noted many interesting points in regard to their pathological history and endeavoured to adduce certain evidence in regard to their presence in plague.

It is not my intention to enter into a deeply scientific description of the pathological appearances of buboes. Such is already well known.

I wish to bring forward my experience in regard to the anatomy of such swellings, the time of their appearance, their growth, their situation, their number, and subsequently to offer certain considerations regarding their origin in the disease.

(1.) *Anatomy.*—The neck, axilla and the region of the groin are the commonest sites of these bubonic swellings. Their anatomy varies in these situations according to their severity. Occasionally it is only an enlarged gland with cortical injection; in other cases, however, the lesion may be widely spread, affecting structures placed at some distance from its focus of origin.

(*a.*) *The Neck.*—Buboes occur most frequently in the submaxillary, submental, supra and infra-clavicular, sub and retro-auricular, and the parotic regions. The skin over the swollen mass is thickened and covered frequently with petechiæ. On section, the mass is œdematous. The hæmorrhagic appearance is not equally intense throughout. The glands are swollen, œdematous, and injected. They are embedded in a densely infiltrated hæmorrhagic mass of connective tissue. The hæmorrhagic infiltration extends along the connective tissue spaces, and surrounds the neighbouring muscles and other structures.

(b.) The Axilla.—The lymphatic glands are periglandular connective tissue form a soft, œdematous mass of varying size. The super adjacent skin is frequently covered with petechiæ. The œdema and hæmorrhage extends into the surrounding tissues to the scapular muscles, the pectoral muscles, the intercostals, down the arm, and up into the region of the neck. The breast in females may also participate and form part of the bubonic swelling. (Bubo paramammario-axillaris).

(c.) The Groin.—The swelling may be femoral, inguinal, or both, with extensions to the iliacal and lumbar regions. The latter is common. The skin over the swelling is frequently covered with petechiæ. The hæmorrhagic infiltration may extend down the thigh to the popliteal region, or upwards over the lower part of the abdominal wall, into the scrotum, under Poupart's ligament into the pelvis and spread over the belly of the ileo-psoas embedding the iliac glands, and the lymphatic duct and cystema chyli, with extensions to the kidneys, pancreas and even the diaphragm.

Rarer situations for the presence of buboes are the region of the tonsil, the popliteal space, the cubital gland, the sacral region, the mesentery, and the glands situated posterior to the liver and about the pancreas.

Date of Onset.—This varies extremely. Buboes may be one of the earliest signs of the disease. In my opinion, they do not appear until certain prodromal symptoms have showed themselves. Many appear within 48 hours of the onset of the fever. In other cases their appearance may be delayed for several days.

Cases have been reported where the bubo or buboes did not appear until the 8th, 9th or 10th day of the disease. The majority, however, are well marked before the 4th or 5th day of the illness.

The Growths.—This is usually slowly progressive. In a few cases this would appear to be absent for some days, and followed by a sudden and rapid increase in dimensions. This is frequently observed in buboes which have been late in appearing. According to Lowson, the prognosis is grave in such cases.

The Size.—They are variable in size. Buboes as large as pigeon's eggs, a man's fist, or even larger, are most frequently found. In a few cases the swelling may never reach a size larger than a hazel nut.

The Distribution.—The results of the post mortem examinations of 788 cases of plague in which bubonic swellings were found, are as follows:—

I. Single Buboes:—

Right femoral bubo,	238
Left femoral bubo,	234
Right axillary bubo,	129
Left axillary bubo,	91
Right inguinal bubo,	26
Left inguinal bubo,	18
Right cervical bubo,	18
Left cervical bubo,	16
Left parotid bubo,	2
Left submaxillary bubo,	1

II. Double Buboes:—

Right and left femoral buboes,	4
Right and left axillary buboes,	2
Right femoral and left cervical buboes,	1
Left axillary and left cervical buboes,	1

III. Multiple Buboes, Case No. I.—Chinese female, æt. 30. Large buboes were found in the following situations:—

(1.) Below and inside Poupart's ligament on the left side.
(2.) At the junction of int. and ext. iliac vessels on the right side.
(3.) In the mesentery.
(4.) In the superior mediastinum.

There was no pneumonia.

The woman was pregnant. A six months' fœtus was extracted. Plague bacilli were found in the maternal placenta. The results of bacteriological examination of the fœtus were negative.

Case No. II.—Chinese male, æt. 35. The following buboes were found:—

(1.) In the right inguinal region.
(2.) Around the left external iliac glands.
(3.) In the right axilla.

In addition to this the whole of the subcutaneous tissue of the right inguinal, and lower parts of the right and left lumbar and umbelical regions of the anterior abdominal wall was œdematous and densely infiltrated with blood. Numerous plague bacilli were found in this tissue. There was no evidence of injury. The infiltrated area did not appear to have any connection with the buboes present.

Case No. III.—A Chinese male, æt. 52. The following buboes were found:—

(1.) Immediately below the left ear.
(2.) Just above the left clavicle.
(3.) In the right axilla.
(4.) In the left axilla.

There was no apparent connection between Nos. 1 and 2. No. 4 had no connection with No. 2. The mesentery contained a large quantity of extravasated blood, in which the lymphatic glands were embedded. The glands were congested with haemorrhagic extravasations. There was also considerable œdema. Every organ and tissue in the body was teeming with plague bacilli.

Case No. IV.—A Chinese female, æt. 18. The following buboes, pigeon egg in size, were found:—

(1.) In the right axilla.

(2.) In the left axilla.

(3.) Around the left external iliac glands.

The haemorrhage around the iliac glands extended over the ileo psoas muscle, ran along the common iliac vessel to the aorta, and was continued upwards to the point of entrance of the inferior vena cava into the thorax.

Plague bacilli were found all over the body. The woman was 7 months pregnant. No plague bacilli were found in the fœtus.

Case No. V.—A Chinese female, æt. 25, prostitute. Buboes were found in the following regions:—

(1.) In the right axilla.

(2.) In the right and left inguinal regions.

The haemorrhagic extravasation in the inguinal regions extended downwards to the vulva. The extravasation was found in the labia as well as around the anterior portion of the vagina. The epithelial lining of the vagina was hyperæmic and showed the presence of a few petechiæ. The portio vaginalis was studded with minute points of haemorrhagic extravasation. The arbor vitæ of the cervix was in a similar condition. The cervix uteri and corpus uteri were œdematous, with mural haemorrhages. Haemorrhages were also found in the ovaries and the broad ligament was the seat of numerous petechiæ. There was little tendency on the part of the extravasation to travel along the iliacs towards the kidneys and diaphragm. The greater part of the hyperæmia and haemorrhage appeared to be confined to the true pelvis. Plague bacilli were found in all organs of the body.

Case No. VI.—A Chinese male, æt. 40. The following buboes were found:—

(1.) In both axillary spaces.

(2.) In the mesentery.

The mesenteric lymphatic glands, particularly those corresponding to the ileum were embedded in extravasated blood. The glands were enlarged, hyperæmic, œdematous, and cortical haemorrhage was well marked. In one or two commencing necrosis was found. This area of bloody tissue was crowded with plague bacilli.

The ileum part of the small intestine was hyperæmic. No hyperæmic or pathological change was found beyond the coecum. Haemorrhages of ranging size had taken place into the submucous membrane of this part of the small intestine. The solitary follicles were enlaged to beyond a pin head in size. Many of these were surrounded by an area of congestion. Peyer's patches were œdematous and were marked only by certain degree of surrounding hyperæmia. All other parts of the large and small intestine were normal to the naked eye.

Case No. VII.—A Portuguese male, æt. 28. Buboes were found in the following situations:—

(1.) In the left iliacal regions.

(2.) In the right iliacal regions.

(3.) In the left cervical region.

Plague bacilli were found in the heart blood and buboes. The haemorrhagic extravasation extending from either iliac bubo met over the lumbar vertebræ, and extended upwards involving the lumbar regions and both kidneys, coming to an end just above the pancreas.

These cases of multiple bubonic formation are of great interest when we look upon plague as being *ab initio* a disease of a septicæmic nature. Given the septic nature of plague, *these buboes must be regarded as secondary to blood infection.*

The swellings may appear early. In fact, they may be existent before many definite symptoms of the disease are present. In other cases, they appear late, during the course of a well defined case of septicæmic plague. The reasons for this variability in the time of their appearance, is by no means obvious. Again such a swelling may be single, double, or multiple, without a satisfactory explanation of the process at work being evident. It has been my experience to find general lymphatic enlargement in ordinary bubonic plague. The glands are moderately increased in size, œdematous and show extravasations of blood especially in the cortical layers.

Not only is this general glandular enlargement found in bubonic plague, but it is met with in cases of other types of the disease. In the purely septicæmic type, this enlargement is one of the commonest changes found post-mortem. In the pneumonic form, *i.e.*, secondary lung plague, the glands are also similary affected. In primary pneumonic plague, hyperæmia and petechial hæmorrhages occur in the lymphatic glands without much evidence of enlargement. This evidence points to the ready action of the plague virus on the general lymphatic system. The evidence gathered from my experience would appear to show that *the disease, no matter what type it ultimately assumes, is of a septicæmic nature.*

In plague, the lymphatic apparatus is one of the first systems to be affected. The plague virus would appear to possess a marked affinity for lymphatic tissue. The preference for certain body tissues is known in bacteriology.

The pathological changes produced by the plague virus in lymphatic tissue is, in my opinion, merely one of degree.

In septicæmic cases with no bubonic formations we find evidence of glandular enlargement. No particular gland or series of glands is affected. All are generally hyperæmic and on careful examination show minute petechial hæmorrhages. Occasionally during the course of such a septicæmia, a bubo may develop out of some of these slightly affected series of glands.

In pneumonic cases, the condition is similar to that found in septicæmic plague. Buboes may complicate pneumonic plague and vice versa.

In the majority of cases of plague, some definite enlargement takes place. This takes place early, in fact, sometimes so early as to be regarded as practically the initial manifestation of the disorder.

Bubonic plague, in the absence of primary pneumonic plague, forms the majority of the cases met with during most epidemics. Therefore we have in plague a disease of a septicæmic nature. The B. pestis multiplies in the general blood stream and primarily exerts its deleterious action on the lymphatic apparatus. In this, swelling, œdema, and hæmorrhagic extravasation take place. These changes are accompanied by a periglandular hæmorrhage, which is diffuse. Evidences are now available as to the action of the virus on the peripheral circulatory apparatus.

Further changes are produced generally in the body, particularly those of degeneration.

Summing up, from a pathological standpoint the various lesions met with during the course of a typical case, one is rather drawn away from the idea that buboes are the result of infection through the skin and mucous membranes in the immediate neighbourhood. *It would appear, on the other hand, that the formation of buboes in the body is dependent on the micro-organism itself, its virulence, and the individual disposition of the person or persons attacked.* Simple hæmorrhagic extravasations are quite as common as buboes. They also occur in fairly definite localities in the body, yet no one has thought them worthy of consideration from the point of view of the focus of entry of the B. pestis into the body.

Many of the septicæmic diseases met with in animals are analogous to plague in man. From a clinical point of view, the appearances presented by such animals, have so resembled plague, that Orientals are firmly convinced that epidemics of a similar disease to plague break out amongst their animals some time previous to the occurrence of plague in man. The condition of septicæmia hæmorrhagica found in cattle in Hongkong resembles plague pathologically. In both diseases do we find general hyperæmia, general lymphatic enlargement, the

occurrence of irregular areas of hæmorrhagic extravasation, pathological changes in the intestines, and the presence of a micro-organism in the blood and tissues of the body.

My results are more or less in accordance with those of BITTER, who regards plague as a septicæmia hæmorrhagica. According to ALBRECHT and GHAR, this is only so in severe cases.

It is said that the occurrence of buboes in definite situations in the body, is strong evidence in favour of the infection having been occasioned through the some focus in the area of tissue drained by the lymphatic glands which are the seat of the bubonic enlargement. Viewing the subject from certain points of view, *e.g.*, the study of the anatomical connections, the question of bare feet, the results of direct inoculation in man and animals, etc., there would appear to be much evidence in favour of such an occurrence.

What we have to consider is the following :—

Does the plague virus reach man in nature, through the skin ? Is this the natural mode of transmission of the disease from man to man ? What avenues in natural infection do we find in animals ? Are the modes of infection the same of man and animals ? Is there evidence of the channels of infection in man ?

The consideration of the points in the presence of a large amount of plague material, has led me to conclude that the opinions arrived at by many investigations are, on better acquaintance, by no means obvious.

In the first place, many cases of plague are not definitely bubonic. The lymphatic glands are enlarged but no series forms a definite bubonic formation. We may have epidemics of plague in which so called septicæmic plague is most prevalent.

Again in epidemics, the bubonic type may be most prevalent.

Different epidemics show great variations in the type of the disease present. A certain annual variation is found. So called septicæmic plague is present during the whole epidemic, but bubonic plague may only be in evidence during certain times of epidemic. Other evidence in regard to these points is given in an attached table showing the relative prevalence of the so called different types of the disease throughout the years 1902-1903.

Further buboes may be double or multiple One may be present in each groin or axilla, or one in the iliacal region, with another in the neck. In other cases of multiple bubonic plague, buboes are found in the most unexpected places. Again it is said that femoral buboes are most common amongst those who go about barefooted, *e.g.*, the Chinese. I find, however, that buboes in this situation, or in the groin, are as common amongst Europeans who are well booted.

In cases of bubonic plague, it is only in rare instances that evidence is forthcoming as to the presence of wounds, abrasions, etc.

It is not denied for a moment, that plague infection frequently occurs through the skin and is followed by the formation of a bubo. In these cases, I am of opinion, that some evidence of such an infection is present on the skin. In animals inoculated by this method, such evidence is usually present, and in all the cases of authenticate infection through the skin which I have come across, there has been evidence of entry of the B. pestis. A papule, blister, a pustule or even a wound present in the skin, and frequently the plague bacillus has been found locally. An excellent example of such an infection has already been given under "Symptoms of Plague."

Such cases do occur, but I am of opinion, they are rare, and do not clarify our ideas to any great extent as to the spread of plague from man to man during epidemic times. In fact I would urge that the importance attached to *skin infection in plague has been exaggerated.*

Again, granting such a skin infection, there is no evidence to show that the B. pestis is shut up in these bubonic enlargements. I believe that general blood infection takes place soon after the introduction of the virus and usually long before the appearance of the bubo. (*Vide* Symptoms of Plague.)

Further instances of bubonic plague are known to follow the bite of a plague rat. (Cases already reported by MAXWELL in his report on Plague in South China, CLARK in his Annual Plague Reports for 1900 and 1901, and SIMPSON in his recent Report on Plague in Hongkong. Cases have also been recorded in India.) Even the bites of plague stricken human beings have produced plague infection. (Austrian Plague Commission.)

In artificially infected animals, bubonic swellings are found. For instance after feeding animals with plague infected material, buboes may be found in the groins.

Mesenteric buboes are also met with in animals. Cervical, submaxillary and parotid buboes may be discovered, yet no injury of the buccal mucous membrane or carious teeth could be held accountable. The tonsils are held by many investigators to be a channel through which the plague virus effects an entry. Great stress was laid upon this avenue of infection by the members of the Austrian Plague Commission. I have frequently examined the root of the tongue and tonsils and found marked œdema of the mucous membrane of the tongue, enlargement of the papillæ, great hyperæmia of the lymphadenoid tissue and tonsils with extravasation of blood. The tonsils may be found twice or three times their normal size. Plague bacilli have been found abundant in these situations. No evidence of such a mode of infection could be traced in experimental animals.

A careful dissection of these bubonic swellings shows us that they are much more extensive than is apparent from the appearance which they present clinically. For instance the bubo met with within the confines of Scarpa's triangle does not in a great many cases represent the focus of most intense pathological change. The bubo in Scarpa's triangle may be quite small. On cutting down on Poupart's ligament we find frequently a continuance of the hæmorrhagic extravasation around the inguinal glands. These are often somewhat larger than the femoral, and the pathological changes are more marked. Further dissection centrally leads us to the external iliacs in and around which one finds most intense lesions. The glands are larger, the œdema widespread, necrosis may be present, and the surrounding extravasation of blood spreads in all directions, namely, over the ileo-psoas muscle reaching the crest of the ileum inwards to the true pelvis invading the broad ligament and its contents, and upwards along the iliac vessels to the aorta, spreading out like a fan over the muscles of the posterior wall of the abdomen and reaching the perirenal connective tissue and organs about the diaphragm. This hæmorrhage frequently joins another mass of blood which surrounds the cœliac glands. The latter are frequently enlarged, œdematous, and extravasates with blood, the group with surrounding hæmorrhage forming a typical bubo. The condition of these cœlic glands is frequently overlooked in making post-mortem examinations on plague cases. The presence of such a lesion is of importance in regard to the gastro-intestinal avenue of infection in plague.

In the great majority of cases, the bubonic swellings are extremely painful. In groin buboes, the pain is located in Scarpa's triangle, often to a small swelling there, while the seat of greatest pathological change is really within the abdomen. This pain may be present for a considerable time previous to the detection of a definite swelling. The pain is probably of the nature of "Referred Pain" of Head.

All bubonic swellings, in my opinion, show the presence of extraneous micro-organisms. The infection with other bacteria would appear to occur early. The micro-organisms most frequently found present are, Staphylococci, Streptococci and B. coli and its varieties. The presence of these organisms appears to act deleteriously on the B. pestis. In advanced buboes these micro-organisms are even more numerous than plague bacilli.

In the majority of articles dealing with the bubonic variety of plague, it is stated that there is an absence of anything like a peripheral lymphangitis. The belief is widely diffused, that the infection takes place, in these cases, through the skin, but the B. pestis, in its passage from the focus of its entry to the seat of bubonic formation, does not excite inflammation. Beyond the possible discovery of the point of entry of the bacillus, therefore, there is no external evidence of the occurrence of such a bacillary infection through the skin. ALLBRECHT and GHON and many others, have laid down, that the absence of lymphangitis is characteristic for plague. Obvious reasons for such a statement do not, in my mind, appear to

be justified. Cases, observed by myself, in which a definite point of entry of the B. pestis could be found, are not confirmative of such a view. So far, my cases showed a definite lymphangitis previous to the occurrence of the bubo. It was slight, but if looked for carefully, could not be missed. An instance of such has already been given under the heading of the "Symptom Complex of Plague."

The persistent absence of anything like an acute lymphangitis in cases of bubonic plague, is, in my opinion, strong evidence against the skin inoculation theory of plague causation. Further lymphangitis has been found present in the lymphatic apparatus leading from the small intestine. This fact is in favour of an alimentary mode of entry of the virus.

Skin infection in plague only after some definite breach of continuity of the skin has occurred. For instance the presence of ragged nails, abrasions, minute wounds are liable in plague infected areas to be infected with plague bacilli and thereby lead to a case of the disease. In the absence of more definite evidence, the question of skin infection in plague appears to be exaggerated.

WILLIAM HUNTER.

The Bacillus Pestis.

This organism has been subjected to so many investigations, its morphological and cultural characteristics are so well known, that one has little to add to its story. The characteristics of the B. pestis as met with in Hongkong are similar to those found in other parts of the plague world. It has been suggested to me by several professional gentlemen familiar with plague, that the type of micro-organism met with in Hongkong is in general smaller than that found in India and other countries. I have paid particular attention to this point, but fail to find the slightest difference. The measurement of bacteria in general is by no means fixed. One has only to examine the morphological records of different bacteria in order to convince one's self of the variations in measurement given by different authors. Again it must be remembered that the B. pestis is an organism which varies extensively in regard to its morphological appearances, and on this alone different measurements would be obtained at different times of examination. In short, I see no reason to believe that the plague bacillus as found in Hongkong differs in the slightest degree from that found in other parts of the world.

The most typical bacilli are obtained direct from the tissues of an animal suffering from the disease. So far as my experience carries me, the bacilli are most frequently found isolated in the human body ; in aminals, however, and particularly in the rat, the B. pestis tends to form short chains, the individual bacilli being markedly bipolar.

The various forms of plague bacilli met with in culture are similar to those already well known.

By the majority of observers, these various forms of the plague bacillus are regarded as Degeneration or Involution forms. That such is the case is by no means obvious, and until further research has been undertaken in regard to the involution forms of micro-organisms in general and the significance of these better known, it would be better to reseve one's opinion. So called involution or degeneration types of plague bacilli are by no means harmless. In fact, such forms we know to possess considerable virulence and are able to reproduce typical infections.

So far I have never observed branching forms of the B. pestis as described by Albrecht and Ghon, Kolle and others. Gotschlich's method of staining with dilute carbol-fuchsin has produced the most uniform result in staining. An excellent method of bringing out the bipolar appearance is that of Gaffky's, namely, the treatment of the specimen with ½ % acetic acid previous to the application of the stain.

By many obsevers, who have had considerable experience of plague, great weight has been laid upon the differential diagnostic significance of the polar staining of the B. pestis. To a certain extent, such a significance is justifiable, but

not to the degree insisted upon by some. *The significance to be laid upon the presence of bipolar and oval shaped bacteria is dependent upon the evidence which one has to suspect plague.* In man the presence of such micro-organisms in a bubonic swelling, in the blood or the sputum, during an epidemic of plague would justify one in concluding that the organisms were B. pestis. *In the absence of plague, however, the mere finding of such bipolar bacteria does not justify such a diagnosis.* The morphological appearances may be very suggestive but in isolated instances like this one requires further confirmation in the shape of cultural and inoculation tests.

Again in man, even during a severe plague epidemic, the microscopic examination of blood smears has to be undertaken with considerable care. In the absence of a bubo, symptoms may be present indicative of some infection, and *a hastily or carelessly taken blood film may show beautiful bipolar bacteria*, which are microscopically almost identical with the true B. petis, yet the further course of the disease and the negative results obtained with carefully taken blood smears clearly prove the case to be something entirely different.

After the results obtained in Hongkong by Dr. Bell and others, all of which I have confirmed, one would require to exercise considerable caution in diagnosing the B. pestis in any blood smear, unless the latter be prepared very carefully. As Dr. Bell noted in a report to the Government in 1903, *beautiful bipolar shaped bacteria can be demonstrated in the saliva, fæces and in various other parts of the body.* I have made similar preparations and have convinced myself that it would be well nigh impossible in many instances to microscopically distinguish such micro-organisms from the plague bacillus. In the past too great weight appears to have been laid upon the mere microscopic examination of a smear coloured with some simple aniline dye like methylene blue. In fact this simple method is regarded by many as sufficient. As pointed out by the various Indian Plague Commission, however, such a rough and ready method, applicable and diagnostic enough in many instances, may lead one to very erroneous conclusions. An important point is noted by the English Plague Commission, namely, the diagnosis of the presence of plague bacilli without the use of other tinctorial methods of examination such as the reaction to Gram's method of staining. In doubtful cases, and more particularly in the absence of an epidemic of plague, such an important tinctorial test should never be neglected. As micro-organisms are known which microscopically resemble the B. pestis, but give a positive result with aniline water gentian violet after treatment with iodine solution.

When one has to deal with the diagnosis of plague in animals, the question of microscopical examination as a sufficiently diagnostic test, becomes one of great difficulty. In Hongkong, where thousands of dead animals are examined for the presence of plague bacteria, the only possible method of examination is the microscopical, and the results obtained by such a method must not be regarded as strictly accurate but only approximately so. *It is now a widely recognised fact that disease in the lower animals is frequently excited by micro-organisms morphologically almost identical with the B. pestis.* In particular one may mention the group of hæmorrhagic and septicæmic diseases which appear to be exceedingly prevalent throughout China, especially the diseases known as cattle plague, fowl cholera and in all probability a variety of swine plague. These diseases are called forth by bacteria which show bipolar staining even more markedly than the B. pestis, and the only differential point between them and the latter, is put down by some as a question of dimension. These hæmorrhagic septicæmic micro-organisms are said to be smaller in size than the B. pestis. As I have already mentioned such a distinctive point is one upon which little reliance must be placed owing to the variations met with amongst bacteria when placed in different surroundings.

Again bipolar staining has been met with in the B. typhi by Gotschlich and micro-organisms are found in rats which have a great resemblance to the B. pestis. Therefore, viewing all the evidence before one, it is clear that the systematic examination of a large series of dead animals for the B. pestis by the microscopic method is liable to lead us to fallacious results. This circumstance has been constantly before my mind since I commenced such an investigation at the Government Public Mortuary, and I have always insisted that the results of my examinations must be regarded as approximate only. It would be quite impossible to do otherwise. The determination of the presence of plague bacilli in strictly scientific

manner in each individual animal would necessitate numbers of assistants and besides entail considerable expense which I think is quite unnecessary. During the past year birds of various species were examined bacteriologically and a few returned as plague infected. As I mentioned in my Annual Report for 1903, it is quite possible that some of these were in reality cases of fowl cholera, but in the absence of cultural and experimental tests, it was impossible to determine the exact nature of the disease in each case.

Similar remarks apply to the presence of plague-like bacilli in rats. Several micro-organisms have been described as occasioning septicæmic disease in these animals, and their morphological appearances are by no means unlike the B. pestis. But as already stated, it is impossible to determine the exact nature of the bacilli in each animal and that the results aimed at are merely approximate.

The difficulties of approaching the diagnosis of the presence of plague bacilli in animals is greatly enhanced by the experiments of SIMPSON and myself showing the possibility of the occurrence of plague infection in almost every animal met with in Hongkong.

The B. pestis has never been found to retain the stain by GRAM's method. KITASUTO's observation in this respect would appear to be wrong.

PITFIELD's method of staining gives excellent pictures of the mucous capsule of the B. pestis. Good specimens of this covering have been obtained from rats.

The B. pestis has never been found to possess the power of motion.

The biological characteristics of the B. pestis met with in Hongkong are practically identical with those found in other parts of the world. HANKIN's method of diagnosis of the plague bacillus has been found of great value.

The B. pestis grows exceedingly well in media prepared with rice. This would seem important in regard to the diet of the native Chinese population.

WILLIAM HUNTER.

The Length of Life of the Bacillus Pestis.

The plague bacillus is a non-sporing micro-organism. So far as we know, its existence as a saprophyte must be very limited.

The experience of those who preserve living cultures of the B. pestis for any length of time, would show that, under certain circumstances, this limited extra-corporeal existence is subject to variation. Pure cultures of the B. pestis, protected from the deleterious action of drying, and light, and kept in a cool place, may remain alive for months or even years.

SCHULTZE (Cent. of Bakt. Bd. 29) kept the bacillus alive for 4 years on MARMOREK's bouillon. GOTSCHLICH (Zeit. of Hyg. Bd. 35, 1900) found his cultures still alive and virulent after seven or eight months.

Of importance for the preservation of the life of the plague bacillus, is a low temperature. By maintaining cultures at a temperature of 20° to 25° C. the B. pestis may be kept alive and virulent for an extremely long and indefinite period of time.

My own results are confirmative of those obtained by the already mentioned investigators. I have kept the B. pestis alive from the end of one plague epidemic to the commencement of another. The organism grew on ordinary agar-agar and bouillon. On fluid blood serum, the length of life of the bacillus would appear to be long but very indefinite. No alteration in the virulence of the organism has been observed. Subcultures of the bacillus need not be made, provided the growths are kept at a low temperature. According to SCHULTZE, the length of life of the organism depends upon certain changes in the bacterial protoplasm.

In dealing with cultures of the plague bacillus it is of great importance to know what virulence these possess.

The plague bacillus would appear to be a most variable organism in this respect. In has been my experience, as well as that of others, that certain strains of the organism maintain their virulence for a long time; others, however, lose this power in a few days.

The reasons for such on occurrence are not clear. Probably the circumstance depends upon the culture medium, its alkalinity or acidity, or upon the establishment of some standard in regard to nutrient media, as recommended by EYRE, would, I think, obviate many of the indefinite conclusions at present arrived at.

The long life of the B. pestis does not obtain in nature. Here many deleterious factors are present. The presence of saprophytes, coupled with the action of heat, cold, chemical and mechanical influences prevent the organism propagating its species for many generations. This fact is of great importance from an epidemiological standpoint. It shows us that the specific germ of plague is unable to spread over a large area without the assistance of either the body of man or the tissues of animals. Again, *the limitation of the life of the B. pestis as a saprophyte, convinces us that, for the dissemination of the disease, infected human beings and animals, e.g., rats, are the chief factors at work.*

WILLIAM HUNTER.

The Avenues of Infection in Plague.

Since the days of the ancients who classified the ways of infection under three headings, namely, contactu, ad distans, and fomité, much has been added to our knowledge in regard to the habits of micro-organisms—pathogenic to man. The life history of these organisms, their biology, and significance in nature have been dealt with fully by many investigators.

The portals through which such organisms gain an entrance into the tissue of man and animals, still remains, so far as many infectious diseases are concerned, a dark chapter. Despite the efforts made by epidemiologists and others to unravel the mysteries of infection, much controversy still exists as to the particular channels availed of by different micro-organisms in order to reach the tissues of man.

The avenues of infection are many. I propose to consider each of them separately and endeavour to show how many of them are of importance in the dissemination of plague.

Amongst the Chinese, certain ideas are widely prevalent as to the propagation of the disease. They attach great importance to infected food. They believe that diseased chickens cause plague. Again reports emanating from the interior of China, make mention that the disease known as Rinderpest in cattle is often found to precede an outbreak of plague.

Further, moist and rainy seasons are said to be productive of severe epidemics of the disease. Dr. ALEXANDER RENNIE in an interesting report on the occurrence of plague in Canton and the surrounding country, arrived at certain important conclusions as to the spread of the disease. In his opinion, rats contaminating food, overcrowding, filth, and bad drainage are responsible for the occurrence and persistence of plague in South China. He notes another important factor that thousands of natives disembark in Hongkong daily from the various river steamers, junks, etc., and that there is no medical supervision or inspection of such individuals. Modern scientific prophylaxis includes such a supervision and inspection among rudimentary principles.

The following avenues of infection are of importance in plague:—

1. The skin.
2. The respiratory tract.
3. The digestive tract.

1. *The Skin.*—The unbroken skin offers the greatest resistance to the passage of all micro-organisms. Even a resistance to chemical reagents is most pronounced.

Instances are known of infectious matter producing disease when energetically rubbed into the skin. The organisms, in this way, reach the sweat and sebaceous follicles and subsequently give rise to disease. Such instances, however, are rare. So far as plague is concerned, the Austrian Plague Commission made the important statement that plague bacilli, when rubbed into the shaved skin of a rat or guinea pig, always occasions a lethal infection. This method has been recommended as a delicate diagnostic test. In my opinion, however, this method of diagnosis loses much of its significance as an instance of skin infection, when we consider whether the shaven skin of such animals is to be regarded as unbroken, with no solution of continuity, or, what is more likely, whether the bacilli make their way through microscopic wounds, the production of which during the process of shaving being almost unavoidable. The question as to the part which the skin plays as an avenue of infection in plague, would appear from my researches to be exaggerated. That such a mode of infection does happen, no one denies. Instances of such are frequently forthcoming. *The evidence at my disposal, however, is decidedly against the general conclusion, that the skin is the common portal through which the plague bacillus effects an entry into the body of man or animals.* The presence of groin buboes as frequently in well booted as in bare footed individuals, the irregular distribution of such bubonic swellings, etc., are against the theory of skin infection. The bulk of evidence amassed by my researches is against the occurrence of such a mode of production of the disease. My experience leads me to the same conclusions as drawn by Wilm, who advanced much logical proof against such a method of infection. If infection took place through the skin, axillary buboes ought to be as common as groin buboes. Again one would expect intense inflammation of the tissues at the point of inoculation similar to that found in animals. One would expect the frequent occurrence of plague in bubonic form amongst those who are employed in special plague work such as the removal of infected rats, clothing and household utensils. These and many other factors already mentioned in different sections of this research are sufficiently pronounced to cast much suspicion upon the questionable role played by the unbroken skin in nature in the production of plague.

2. *The Respiratory Tract.*—The introduction of the plague virus, *viâ* the respiratory tract, is a most important mode of production of the disease. Primary pneumonic plague is produced by the so-called drop-infection of Flügge.

The air cannot be regarded as dangerous. The B. pestis does not survive dessication, and possesses, so far as we know, no permanent forms, enabling it to continue its existence as a saprophyte. The plague bacillus cannot exist in the air as dust. This statement is amplified by the non-occurrence of cases of the disease amongst those in charge of plague patients or in special plague work. Had the B. pestis an aerial existence we should expect to find numerous instances of such a mode of infection amongst those in close contact with the disease. Further such a mode of dissemination would be further accelerated by the increased virulence possessed by such plague bacilli present in the lung tissue. (Kolle and Martini, Deut. Med. Wochen. 1902.)

Close contact with the disease and direct transference of the moist particles of pestiferous sputum are necessarry for infection to take place through the respiratory tract. This explains the many dreadful visitations of the disease which one frequently hears of, where whole families have been exterminated in a few days. Primary pneumonic plague would not appear to be as common now-a-days as formerly. Such a form of plague differs entirely from the other varieties of the disease.

Primary pneumonic plague, where present, does not, like septicæmic plague, occur broadcast over a town or city. The cases are at first localised. The disease shows a steady march, blotting out of existence whole families or congregations of people.

This form of the disease would appear to be rare in Hongkong. The varieties found are mostly secondary pneumonic manifestations occurring as complications of ordinary septicæmic plague. Details in regard to these forms of disease have already been given under the "Post-mortem Appearances of Plague."

3. *The Digestive Tract.*—The intestinal canal is the starting point of a large number of acute infectious diseases. That plague should be included in the list of such diseases has been the subject of much varied discussion. The majority of

those specially engaged in plague work in India and elsewhere, opposes the view that the disease is of alimentary origin. The evidence upon which such opposition is based is by no means obvious. *My researches would appear to relegate to the alimentary canal, a most important part in the production of the disease and as a focus of entry of the B. pestis into the body*, and the grounds upon which this conclusion is based are the following :—

(1.) The symptoms complained of by plague patients during the earliest stages of the disease are referrable to the gastro-intestinal tract. Diarrhœa and vomiting are frequently the first signs of the disease.

(2.) The gastro-intestinal manifestations are frequently—if not in most instances—well marked previous to the appearance of anything like a peripheral bubo or secondary pneumonia.

(3.) The negative results obtained were after a most careful enquiry and examination as to the question of skin inoculation of the virus.

(4.) The presence of gastro-intestinal symptoms in plague infected individuals in whom a definite focus of skin incorporation of the plague virus was present.

(5.) The condition found in the gastro-intestinal tract and neighbourhood on post-mortem examination is strongly suggestive of alimentary incorporation of the B. pestis. For details, *vide* the "Results of Post-mortem Examination."

(6.) The B. pestis is present in hoards in the fæces of man and animals suffering from plague.

(7.) The B. pestis may be demonstrated in large numbers in the mucous membrane and other coats of the gastro-intestinal gut.

(8.) The B. pestis may reach the small intestine by way of the mouth without much chance of injury. The bacillus is capable of resisting the action of dilute acids for an appreciable length of time. The amount of acid, namely, hydrochloric acid, present at any time in a normal stomach, is about 0·02 %. The B. pestis would appear to be able to withstand the action of such a quantity of acid. Wilm states that plague bacilli live for 2 days in ½% of hydrochloric acid. The German Plague Commission found that pure cultures of plague bacilli were killed by the action of 1 in 1,000 solution of hydrochloric acid only after half an hour. Gianna and Gosio state that 1 in 100 hydrochloric acid kills the B. pestis in one hour and a 0·5 % solution of the acid only after six hours.

The B. pestis is evidently little affected by the gastric juice.

(9.) The pathological changes found in the mesentery are suggestive of alimentary contraction of the disease. The general enlargement and œdema of and hæmorrhagic extravasation into and around the mesenteric lymphatic glands with the presence of enormous numbers of plague bacilli in such foci speak for such a mode of introduction of the virus.

(10.) Experimental evidence in animals yields constant positive results. Pigs, fowls, sheep, monkeys, etc., if fed on plague infected material contract the disease with certainty.

(11.) Infection per os in plague is the most certain means of production of the disease in animals.

(12.) The post-mortem appearances found in artificially infected animals are strongly in favour of an alimentary mode of infection.

(13.) The B. pestis is found in great numbers in the fæces of animals suffering from plague.

(14.) The rat is infected per os. This is the usual mode of infection in this animal.

(15.) Food and articles of diet have been found infected with the B. pestis. (*Vide* "Food in relation to the Spread of Plague.")

(16.) Vermin such as flies, cockroaches, beetles, ants, rats, mice, etc. may harbour plague bacilli and convey the virus to food used by man or animals. These animals have been found to contain plague bacilli. (*Vide* "Results of Examination of Insects for Plague.")

(17.) Certain experiments with cockroaches furnish strong evidence in favour of plague infected food as a method of spread of the disease. (*Vide* "Pound's Experiments and own Results under Insects in relation to Plague.")

(18.) The results obtained with flies infected with plague bacilli. (*Vide* "Results on Sugar.")

(19.) The long length of life of the plague bacillus which is possible on different fruits and prepared foods.

(20.) The strong evidence that articles of diet, cooking utensils, and water, may become contaminated by man himself, either through infected fingers, clothing, etc.

(21.) The danger attached to latent cases must be borne in mind.

(22.) The evidence brought forward by Wilm, Jansen, Bitter, etc.

WILLIAM HUNTER.

The Paths of Elimination of the Bacillus Pestis.

A knowledge of the paths of elimination of the Bacillus pestis from the bodies of plague patients and animals is of the highest importance from a prophylactic point of view.

In plague, no matter what variety of the disease is present, the causal agents are scattered broadcast by those infected.

In primary pneumonic plague, the sputum, which is abundant, is simply teeming with an extremely virulent race of plague bacilli.

In septicaemic plague, with its complications of bubonic formation or secondary lung lesions, the excretions and secretions represent extremely potent sources of the spread of the infection.

In dealing therefore with the disease from a prophylactic point of view, it is of the highest importance to be *au fait* with those channels through which the causal agent leaves the bodies of the infected.

Such an elimination of the plague virus may be occasioned by two ways:—

1. Directly discharged from a focus of the disease.
2. Discharged through the blood with the normal secretions and excretions.

1 *Direct Elimination.*—For such to occur it is necessary for the focus of the disease to be in direct communication with the outer world.

The opinion is widely diffused that cases of bubonic plague are not dangerous. They are not sources of infection. Consequently such cases would not come under this heading. In my opinion, however, such varieties of the disease are merely manifestations of a general septicaemic disease. This being so, all secretions and excretions from patients suffering from septicaemic plague, must be looked upon as possible sources of infection. Direct elimination of the B. pestis would appear to be possible through the following channels:—

1. Through the respiratory channels.
2. Through the fæces.
3. Through the urine.
4. Through discharging buboes.

Other possible channels of elimination are possible, but are not to be included under direct elimination.

(1.) *Through the respiratory channels.*—In cases of primary pneumonic plague, such a mode of elimination is of the highest importance. Hoards of plague bacilli are expired or expectorated by such patients, and the spread of infection may be occasioned either directly by so called drop infection, or indirectly through other channels. The question of communication of plague infection by this means has already been dealt with in another section of this research. In cases of complicating consolidation of the lung in septicæmic plague, the sputum is also found teeming with plague bacilli Whether the bacilli contained in such a sputum would effect an equally great chance of infection is a matter of doubt.

Again in cases of ordinary septicæmic plague apart from lung complications, there is reason to believe that occasionally plague bacilli may reach the outer world through such a channel as the sputum.

It would be advisable to regard all saliva and sputum of plague patients as sources of great danger.

In cases of plague, the disinfection of all matter discharged per os, ought to be a matter of ordinary routine.

(2.) *Through the fæces.*—In animals suffering from plague, the type of disease is septicæmic, and the disorder is called forth with the greatest of certainty through the gastro-intestinal tract. The B. pestis in animals is more or less constantly found in the fæces. In the rat, this is especially the case.

In man, there is much evidence in favour of an alimentary incorporation of plague infection. The symptoms presented during life, coupled with the pathological changes met with post-mortem and the bacteriological demonstration of the presence of plague bacilli in the fæces during life and the intestine after death, are much in favour of the gastro-intestinal tract being at least one of the principal foci of entrance of the B. pestis into the tissues of man The presence of diarrhœa, constituting the evacuation from the bowel of considerable quantities of fluid or semi-fluid material, is an element of great danger. The condition is analogous to that found during the first half of an attack of enteric fever.

Again the vomit must be treated with suspicion. Plague bacilli have been found in these discharges from the stomach. Wilm and other writers make mention of the presence of the B. pestis in this fluid.

Like the sputum, therefore, all discharges from the gastro-intestinal tract, ought to be systematically disinfected, as these constitute elements favouring the spread of the disease.

(3.) *Through the urine.*—This mode of elimination would perhaps come better under indirect methods of the discharge of the infection That plague bacilli are frequent contents of the urine has been firmly established. The condition is similar to that found in typhoid fever and other diseases. It is doubtful in such a thing as a typical plague bacteriuria is ever found. Probably an explanation similar to that which obtains for the occurrence of typhoid bacteriuria is applicable to plague, namely, the passage of stray plague bacilli through the tubules of the kidney and their appearance in the urine. It is known that the B. pestis resists the action of minute traces of acid for some considerable time. The urine of plague patients ought to be disinfected in all cases.

(4.) *Through discharging buboes.*—It is generally believed that the younger the bubo, the purer the culture of the B. pestis found therein. Secondary infection of such bubonic swellings soon occurs. How soon, is difficult to say, and likewise, the true explanation of the effect of the micro-organismal association, namely, plague bacilli plus pyogenic bacteria, is difficult to give. It is well known that the latter grow luxuriantly to the extermination of the former, and that in well marked suppurating plague buboes, plague bacilli are difficult to find.

It would be interesting to determine, how far these secondary infecting organisms go in the production of the typical plague bubo with its spreading and far reaching haemorrhagic extravasation.

In general terms, it may be stated, that secondary infection with pyogenic bacteria occurs during the earliest stages of bubonic formation. The B. pestis is abundant during the first stages of the bubo. During the later stages, the B.

pestis is absent or at least difficult to find. I have never yet been able to make cultures direct from such buboes, even although these were just developing. Notwithstanding the utmost precautions, cocci were always found present, and the presence of these were even found in microscopic preparations of smears of the bubo, stained by GRAM's method. In conclusion, my experience leads me to believe that the puriform discharge from a suppurating bubo, is not dangerous so far as plague infection is concerned.

II. *Indirect Elimination.*—In order for such a process to take place, *two conditions must be fulfilled. In the first, the causal germs must be present in the blood stream, and in the second, these germs must pass the barriers set up by the secreting epithelium.* In my opinion, the first of these conditions is fulfilled in the case of plague. It is in reality a septicæmic disorder. The B. pestis is found in the general circulation and multiplies there.

The fate awaiting the bacilli in the blood is of a varied nature. The bactericidal action of the blood itself accounts for the death of a few bacilli. Others meet their end in the spleen and bone marrow. The pathological condition of the blood is of great interest in plague. There would appear to be little known in regard to its conditions in such a disease. Several interesting points have been observed by myself in regard to plague blood, but I do not venture to furnish details at present owing to the incompleteness of my results.

In regard to the part played by the various secretions and excretions, one may say the following. The kidneys, under physiological circumstances, do not eliminate micro-organisms (WYSSO-KOWITSCH). In plague, the kidneys almost always participate in the general pathological process. Albumin is present in the urine, and there is every reason to believe that plague bacilli are actively eliminated in the urine.

Just as in other diseases, the condition of the urine, and other excretions are of great importance in regard to their infectivity in convalescent cases of plague and in latent cases of the disease. In typhoid and many other infectious diseases, the causal agents are known to harbour in the body for considerable periods of time. They rarely reinfect an individual who harbours them, but are of sufficient virulence to occasion widespread infection.

In plague, the same method obtains importance. Such bacilli are either constantly or periodically discharged from the body and unless destroyed constitute fresh foci of infection.

The question in regard to latent cases in plague is of equally great significance. That latency in infectious disease is an important factor in influencing the principles of prophylaxis is becoming more and more recognised daily. I see *no reason to doubt the occurrence of latent plague in man.* The researches of GOTSCHLICH, BITTER and many others are a sufficient guarantee of its frequent occurrence *I am convinced of its presence amongst rats.* Many instances of such in rats have come before my notice.

Latent plague in rats would appear to be an important factor in regard to the bridging over of plague epidemics in rats and man.

I have no data of my own in regard to the elimination of the B. pestis through the other secretions of the body, *e.g.*, the salivary, lacrymal, intestinal or sebaceous glands, etc.

WILLIAM HUNTER.

The Significance of Air as a Carrier of Plague Infection.

The significance of air in the spread of infectious diseases has been thoroughly investigated by FLÜGGE and his school. It has been demonstrated that the transmission of disease by such a means must be occasioned by one of two methods:—

(1.) By dust.

(2.) By so called drop infection.

The part played by air in the dissemination of infective diseases is dependent upon the vitality possessed by the causal agents of these diseases. If the exciting agent be capable of an extracorporeal or saprophytic existence, air will obtain an important place amongst the methods of spread of such an infection. On the other hand, and this is true of the majority of infectious diseases, should the pathogenic bacteria be obligately parasitic or facultatively saprophytic, the chances are against the air playing an important role in the spread of such diseases.

The latter is true of plague. The B. pestis thrives best in contact with living tissues. On reaching the external air it meets with many harmful influences. These render it innocuous or cause its death.

The possibility of the transmission of plague infection through dust may be passed over as unimportant.

The spread of plague by so called *drop infection*, however, *is of great importance*. This method of conveyance of infective viri, has been the subject of thorough investigation by Flügge and his pupils, and its significance as a mode of the spread of pathogenic micro-organisms has become widely recognised during the past few years.

By drop infection, we mean, the direct conveyance of infective viri from one person to another by means of microscopic particles of sputum. Such particles of sputum are widely diffused into the external air during the acts of speaking, coughing, or sneezing, etc. In this way, it is possible for plague bacilli in the sputum of plague infected individuals to be scattered broadcast into the surrounding atmosphere, the infected particles probably being inhaled by persons in the immediate neighbourhood. It must be borne in mind that such a spread of infection does not take place at any considerable distance. Actual contact or close association with such plague patients would appear necessary in order for the occurrence of infection.

In plague, the part played by drop infection is limited almost entirely to cases of primary pneumonic plague. In this type of the disease the bacilli ejected with the sputum are said to possess high degrees of virulence. Considerable risk, therefore, is run by medical men, nurses, and attendants on such cases, especially so should they be in close association with pneumonic plague patients at a time during which any sudden respiratory effort is made.

The actual sputum itself, does not appear to possess any terrors. The collected sputum is of no greater danger than any of the other infected secretions or excretions.

The sputum in cases of so called secondary pneumonia in septicæmic plague, is also dangerous, but less so apparently than that ejected by patients suffering from primary pneumonic plague.

In ordinary cases of septicæmic plague, with or without bubonic formations drop infection is of no importance.

The history of plague epidemics in recent years appears to relegate to air infection in general no important part in the spread of the disease. In the accounts of plague in India we find mention made by the members of the Austrian, German, and English Commissions, etc., of the apparent immunity of attendants in plague hospitals.

Müller, of the Austrian Plague Commission, states that during the epidemic in Bombay none of the attendants contracted plague. They were constantly in close contact with all types of the disease, they nursed the cases, cleansed them, removed the sputum, fæces, and other excreta, washed the clothing and bedding, yet not a single instance of plague occurred amongst them.

Again the majority of them were barefooted, and frequently had abrasions on their feet. Further, medical officers in charge of plague hospitals do not contract the disease. Again, patients presenting indefinet symptoms are frequently sent to Hospital for observation. They are soon diagnosed as ordinary pneumonia, malaria, etc., and treated accordingly. Such patients frequently have to lie n a bed alongside a pronounced case of plague. The ward may be full of other

plague cases. There are few if any authentic instances where the disease has been communicated to such patients after their admission into the ward of a plague hospital.

The experience in Hongkong is the same. WILM reported the rareness of the disease amongst those engaged by the Sanitary Authorities to carry out the removal of plague cases and the disinfection of plague infected houses.

I have also observed the relative insusceptibility of the attendants on plague cases in the Kennedy Town Infectious Diseases Hospital.

In wards full of plague cases of all types of the disease, the air, if it were a fertile ground for the dissemination of the infecting attendants, medical men, etc., who, beyond washing their hands in dilute Jeye's fluid, take practically no other precaution.

The report of the various Commissions, and in particular the Indian Plague Commission, are strongly against the air as a spreader of plague infection.

They state: *Plague does not spread in a hospital. It has been stated in India that the ward of a plague hospital is one of the safest places during an epidemic.*

Again plague *patients have been treated successfully in well ventilated rooms of their own residences* without any extension of the disease to the other inmates of the house.

The importance of the spread of plague by air is apparently insignificant.

That such a thing does occur is true. Generally speaking, primary pneumonic plague is mainly spread by drop infection. Septicæmic plague is in all probability rarely spread by dust or air.

Pneumonic plague cases ought to be strictly isolated. Septicæmic plague cases may be isolated, provided there exists a well equipped Infectious Diseases Hospital.

The reports made by THOMPSON on the treatment of plague in Sydney are confirmative of the foregoing. In hospitals in the tropics, there would appear to be little chance of the spread of a disease like plague through the air. With open doors and windows, etc., the chances of such a mode of infection are reduced to a minimum. In such free air there is an enormous dilution of the infectious material and this is supplemented by air currents producing energetic mixing and rapid transport of pathogenic germs.

Further, pathogenic bacteria soon disappear from the air. They adhere to floors, walls, trees, etc., and die as the result of various well known extraneous and deleterious influences.

Even although these germs are in the vicinity of man, they can rarely be inspired by him owing to the weak suction power of his inspiratory stream, compared with the much greater velocity of the wind-driven infectious material.

Until quite recently our ideas in regard to the bacterial content of the air, and its role in infection, were much exaggerated.

Recent investigations, particularly those made by FLÜGGE's school, have clarified our opinions in regard to this medium and considerably reduced the importance of air as a medium of infection.

WILLIAM HUNTER.

Water and Water Supplies in Plague.

Plague would appear not to be spread by water. Opinions are widely divergent as to the length of life of the B. pestis in water.

In ordinary tap water, I have kept the organism alive for 15 days at the room temperature during the cool season of the year.

In distilled water, which in itself is bactericidal, it dies in about 3 days.

Its length of life in sea water would appear to be longer. This may be due to the presence of quantities of sodium chloride. WUNTZ and BOURGE found it alive in sea water after 47 days.

After viewing all the evidence available in regard to the presence of plague bacilli in water, one may conclude that the chances are against such a mode of infection. The strict supervision of water supplies and the recommendations of the Venice Conference in regard to water tanks on ships, etc., in the presence of infection, must be attended to, but there is no necessity to push the preventive measures further than the general principles underlying the continual preservation of a supply of good potable water.

Amongst the native population, water used for potable purposes may become contaminated, and wells, etc., may become dangerous for the time being through the infection of the water with fœces and urine.

Instances of this are only exceptional. The B. pestis and its relation to water would not appear to have the same significance as in the cases of the Bacillus typhosus and the Vibrio cholerae.

WILLIAM HUNTER.

The Chances of Infection from Plague Corpses.

In almost every country where plague is rampant, the question has arisen as to the disposal of the bodies of individuals and animals dead from the disease.

The opinion is widely diffused amongst the laity, and even among a certain class of physicians, that such plague corpses are sources of great danger, and that special precautions ought to be taken to insure the general public against any chance of infection from such a source. Such a general expression of opinion, is given even at the present day.

In many countries where plague is endemic, one finds isolated areas of ground set apart for the reception of every plague corpse. Such is designated "The Plague Cemetery."

These views have been handed down to us by our forefathers. They still hold sway in the minds of those in authority. They must be relegated to the pre-bacteriological era of our knowledge of infectious diseases, a time during which, practically no proof was available as to the exact meaning of the term infection, the agents of infection and the different modes of dissemination of infection.

With a possession of the knowledge of many of the causal agents of specific infectious diseases, many of the narrow minded and dogmatic principles of prophylaxis of olden time, have disappeared. We are in a much better position to-day to assert, what is and what is not dangerous to public health.

In the case of plague corpses, man or animal, all the evidence available, and such is bulky, shows that properly buried plague corpses are in no degree more dangerous than other dead bodies.

In fact special plague cemeteries, from a health point of view, are of no value.

Such a statement is made upon facts ascertained by direct observation and experiment.

Plague bacilli have an extremely limited existence in the dead body. It must be remembered that this organism, so far as we know, possesses no means of preserving its species for an indefinite length of time outside the living tissues of man and animals. We know of no prolonged saprophytic existence of the B. pestis.

The behaviour of the plague bacillus in a plague corpse is something after the following.

During the first twenty-four hours after death the B. pestis multiplies rapidly. Subsequent to this period and the death of all the organs and tissues, the organism becomes less numerous, lost in the colossal growth of the numerous saprophytes, present in all dead bodies, and rapidly dies.

The longest time on record for the persistence of the B. pestis in a dead body is 30 days (YOKOTE, Cent. f. Bakt., 1898).

It is extremely probable, however, that in most cases, the bacilli are dead long before this time. The observations have usually been on the dead bodies of small animals, *e.g.*, Guinea pigs. In the human body, the chances are that the plague bacillus would survive for a much shorter period of time.

Further, a good deal depends upon the general nourishment of the body. Plague corpses do not usually present much abnormal in this respect. Climatic influences also affect the life of the B. pestis. In a semi-tropical climate, like that of Hongkong, where decomposition is usually so rapid, plague bacilli must quickly disappear, or be rendered inert within a few days after the death of the individual.

Again, plague bacilli have never been found in the earth surrounding coffins containing plague corpses. This is important when we remember that the length of life the B. pestis in ordinary earth may be considerable. GLADIN (Cent. f. Bakt., 1898) found the organism alive after one to two months.

WILLIAM HUNTER.

The Spread of Plague Infection by Insects.

The spread of bacterial infection in general by insects has been the subject of widespread discussion within the past few years. This is due mainly to the possibility which has arisen in regard to the mode of infection in plague and the possible spread of the disease by such means.

The spread of infection by insects is by no means a new subject. It has been discussed for ages. So far as plague is concerned, history supplies us with very early records of its supposed spread by way of insects.

In the year 1498 Bishop KNUD of Aarhus noted "that the first sign of the approach of plague is a change in the weather with excessive fog and rain and the appearance of large numbers of flies."

This observation seems to have been forgotten because, until quite recently the role played by insects in the spread of plague or even other infectious diseases, was passed over as unimportant and undeserving of scientific investigation.

During recent years, however, quite a revival of the old doctrine has taken place, and numerous contributions have been made to scientific literature in regard to this subject.

The literature is so voluminous, fragmentary and scattered, that it has only been after careful and prolonged searching, that anything like a comprehensive review of the present state of our knowledge, has been possible.

It has seemed probable to many investigators that insects do play an important part in the spread of infection. In certain diseases, there is no doubt of the fact. One has only to live in a country which is malarious to satisfy one's self as to the role played by these pestiferous mosquitoes, namely, the species of anopheles.

The East may be regarded as the breeding ground in chief of all sorts of insect life and such is rampant in China. Opportunities are afforded in the far East for the study of such species, and in a place like Hongkong, no better chances could be offered to establish or disestablish the doctrine of the insect spread of plague. Leaving the subject of plague for the present, it seems necessary, in order to grasp the subject under consideration, to consider certain points. Summing up the means at the disposal of insects for the transmission of an infectious virus, we arrive at the following:—

I.—The factors necessary for the infection of the insect.

(*a.*) The deposition of germs on the surface of the insect.

(*b.*) The introduction of viri into the intestine of insects.

(*c.*) The virulence of the virus infecting the insect.

II.—The mechanism of the infection.

(*a.*) In suctorial insects.

(*b.*) In non-suctorial insects.

III.—The relations between insect species and animal species.

IV.—The relation between infected clothing and suctorial insects.

V.—The infection of food, etc., by insects.

I. The factors necessary for infection of insects.

If an insect comes into contact with micro-organisms of an infectious nature, the latter may be deposited either on the surface of the body of the insect, *e.g.*, the feet, wings, etc., or in the alimentary canal of the insect.

(*a.*) *Deposition of germs on the surface of the insect.*

It must be admitted that such a deposition is an every day occurrence. The bodies and appendages of insects are covered with bacteria of all kinds, the nature of the latter being dependent upon the surroundings. Under ordinary conditions and in the absence of infectious diseases, the occurrence of such micro-organisms on the body surfaces of flies, etc., is of no great practical importance.

It is only when we have to deal with diseases known to be caused by pathogenic bacteria and to which germs, insects may have access, that the question becomes one of great epidemiological importance.

Quite a number of researches have been published dealing with the presence of pathogenic bacteria on the body surface of insects.

Cholera vibrios have been found by Simmonds on flies (Centralb f. Bakt, Bd. IV), anthrax bacilli by Heim on various insects (Compt. rend. No. 3, 1894). and Proust and Yersin have made similar observations (Bullet. de l'Acad. de Médicine, 1894).

During the epidemic of plague in 1903, I had the opportunity of examining a large number of flies. At the Public Mortuary flies were a great pest during the summer months. A similar condition of affairs was found in the Kennedy Town Infectious Diseases Hospital. The flies from both places were frequently examined bacteriologically for plague bacilli. From the attached table, it is seen that at least 75% of such examined showed the presence of plague bacilli. The presence of plague bacilli on the bodies of the flies did not appear to affect their life. There was no increased death-rate amongst flies during the epidemic of plague.

The bacteriological examination of these insects was conducted in the following way. The flies on being caught were soaked in sterile normal saline or in bouillon. From this plate cultivations were made. The results were usually verified by animal experiment. Again, in other cases the flies were broken up in similar solutions and the routine methods proceeded with. The results obtained after washing the body surface of the fly were only occasionally positive. Those obtained from the crushed insect were highly satisfactory. One must remember that it is possible to obtain a negative result from the washings of the body surface, but a positive result from the contents of the alimentary canal and *vice versa*.

Further, it is also probable that flies may convey plague bacilli on their backs so to speak for some considerable distance.

Small pieces of sugar, previously tested for the presence of plague bacilli, introduced into sterilised test tubes containing plague infected flies, have been found to contain plague bacilli when tested experimentally.

This is a most important observation from a domestic point of view, especially during plague epidemics.

I cannot confirm the statements of Nuttall (Centralb. f. Bakt. Bd. 22) and Yersin (Annal. Pasteur. Tome 8, 1894) that flies die soon when infected with plague bacilli. As has been already mentioned, I have never seen an increased death rate amongst these insects during plague seasons.

Again, mosquitoes of the Culex variety have been examined for plague bacilli but always with a negative result.

Pediculi of several species also gave negative results.

Bugs, on the other hand, I have found, according to the methods already described, to harbour plague bacilli on the surface of their bodies. Cockroaches (Blatta orientalis) also preserve plague bacilli on their body surfaces. This again is important, as the disgusting insect is found in large numbers, especially in store rooms and cupboards. About the same time as I was carrying on my experiments, similar observations were being made in the Health Department of Brisbane by Mr. C. J. Pound. Extremely strong evidence is brought forward in favour of the role played by cockroaches in the transmission of plague. The following was noted by Mr. Pound. "In a room specially set apart for keeping all inoculated animals were two large stands with wide shelves on which long lead lined trays about two inches deep, and containing carbolic acid, were placed. Standing in these trays and surrounded by the carbolic acid solution were various strong glass jars containing experimental animals. Each jar contained only one animal—a Guinea pig, rat or mouse. The jars were covered with a mosquito proof fine wire gauze lid. On one occasion a healthy Guinea pig, that was being kept as a control for certain experiments, suddenly became sick and after three days it died. Post-mortem and bacteriological examination proved that this Guinea pig had died from a generalised form of plague, but no lesion was found to indicate that it had been infected through the skin. A careful examination revealed the fact that in the zinc binding of the wire cover there were several very young cockroaches. These were promptly destroyed. On examination of the covers of the other adjoining jars, more young cockroaches were discovered. These cockroaches had become hidden in the zinc lining of the covers when the jars were not in use, and standing on the shelf alone, unprotected by the tray of carbolic solution. As soon as a jar was occupied by an experimental animal the cockroaches that had been hidden from view in the zinc lining during the day time would, after dark, crawl down the inside of the jar and feed on the animals' food. Apparently, before their presence was discovered some of these cockroaches had fallen from a jar containing a plague infected animal into the carbolic solution, and then swam either to the jar containing the healthy Guinea pig or to the side of the tray, and then hid away in the cover of an empty jar. In any case it was more than probable that the food had become contaminated with plague bacilli.

In order to ascertain whether the cockroaches had anything to do with the transmission of plague, a healthy Guinea pig was placed in a sterilised jar covered with the usual wire lid, but whose zinc lining was free from cockroaches. The jar was placed on the shelf, but not on the tray. In the course of a few days young cockroaches made their appearance and, as usual, lived during the day time in the zinc lining. Eventually the Guinea pig sickened and died of plague.

After this experience, the whole of the building and everything such as shelves, benches, jar, etc., were subjected to thorough and repeated disinfection and all holes and crevices carefully closed. The result is that no cockroaches have been seen since, and although every day during the past eight months numbers of plague and healthy Guinea pigs and rats have been kept in the same jars and standing in the same trays, no symptom of the disease has appeared in any animal unless specially infected."

In my opinion the lesson taught us by this experiment is of great importance. My own result showed the presence of plague bacilli on the body surfaces of this insect, and also in its alimentary canal. Coupling these two results together, therefore, we have strong evidence in favour of the fact that cockroaches disseminate plague bacilli. As is well known these insects are most frequently found in houses, and particularly in places where food stuffs are conserved. A conclusion which appears justified from these results, is that *in all probability cockroaches play an important role in plague infected districts, and that extreme danger exists when these insects can gain access to plague infected places, and further that in all probability food stuffs are frequently plague infected by contact with cockroaches on or in which plague bacilli are present.*

(*b.*) *Introduction of Viri into the Intestine of Insects.*—Just as in the case of germs on the surface of the body of insects, so also do we find bacteria of the most varied species in the alimentary canal of these animals. The majority of such micro-organisms are harmless and non-pathogenic for man. In certain cases, however, bacteria may be present in the digestive tract and excrement of insects which are capable of setting up disease in man. By their presence in the fœces of these animals, such pathogenic micro-organisms may become widely scattered in nature, and the role played by such insects of the greatest importance in regard to the spread of certain diseases. The evidence is very strong that infectious material may be widely disseminated in nature through the excrement of insects. Research and experimental study have pointed to the great possibility of such an occurrence in nature.

Spillmann and Haushalter (Baumgarten's Jahresberichte, Bd. III, 1887) have found the Tubercle Bacillus in the fœces of flies fed on tubercular sputum and a searching investigation by Celli (Bull. del. Soc. Lancis. deg. osped. d. Roma. Fasc. I, 1888) showed that by feeding experiments, the tubercle bacillus, vibrio choler, bacillus typhosus, bacillus anthracis, and staphylococcus pyogenes aureus, could be recovered from the dejecta of the artificially infected flies. Sawtchenki (Revue d'Hygiène, Tome XV, 1872) succeeded in cultivating the vibrio choleræ from the fœces of flies fed on cholera bouillon. So far my own experiments have been limited to the plague bacillus. After numerous experiments, the B. pestis has been found in the alimentary canal and fœces of flies. Such plague bacilli were found to be virulent, and set up typical plague in artificially inoculated animals, *e.g.*, the rat. Large numbers of the flies caught in the Public Mortuary were found to contain plague bacilli in their fœces. Of those caught in the Infectious Diseases Hospital, a much less number were found infected in this way. These facts alone, prove how widely *such insects as flies may disseminate the specific germs, and show us that in plague infected areas, every precaution possible ought to be taken to prevent access of flies to infected material.*

Again, I have obtained similar positive results with bugs, spiders, and a few cockroaches. These experiments show us the possibility of micro-organisms finding a refuge in the body of an insect where it may multiply indefinitely and by way of its excrement distribute its progeny over wide areas. That is to say, given such an occurrence we have before us a means whereby any particular species of pathogenic micro-organism may become widely diffused in nature and give rise to widespread disease. In Hongkong, where insects abound and become in themselves a pest, ample opportunity is afforded for the spread of plague by such means. Foods, articles of diet, cooking utensils, fruit, etc., are constantly being attacked by such insects, and should the latter be infected or their infected dejecta be deposited on such articles, the conditions necessary for the spread of the disease are complete. Many of the foods consumed are cooked previous to their being used, but fruits and many articles of diet used by the Chinese which are swallowed in the uncooked or cold condition are liable to the grossest contamination.

(*c.*) *The Virulence of the Virus infecting the Insect.*—In connection with this point, it is important to bear in mind that although the infection of the insect is natural and the bacteria in question are living and virulent, there is a vast difference so far as the possibility of conveyance or infection is concerned between micro-organisms which are deposited on the surface of the body and those which are introduced into the alimentary canal. Heim (Compt. Rend. No. 3, 1894) has found living and virulent anthrax bacilli on the surface of the body of various insects. Proust (Bullet. de l'Académie de Médicine, 1894), Yersin (Annal. d'Hygiène, 1899) and others have made similar observations. Simmond (Annal. Pasteur. Tome 12, 1898) found the vibrio cholerae deposited on the surface of the bodies of flies. The effects produced by drying, killed these vibrios in 1½ hours.

In regard to the intestine, the reports of different investigators vary. Celli (Bulletin Lancisiana, 1888) and Alessi have found living anthrax bacilli in the dejections of flies. Sawtchenki, (Rev. d'Hyg. T. 15, 1892), Hofmann (Korrespondenz-blatt, Sachsen, 1888, No. 12) and others found cholera vibrio in the intestines of insects.

And what is most important, YERSIN (Annal. Pasteur, T. 13, 1899), WILM (Hyg. Rundschau, 1897), ABEL (Cent. f. Bakt. Bd. 21), HANKIN (Cent. f. Bakt. Bd. 22), SIMOND (Annal. Pasteur, 1898). NUTTALL (Cent. f. Bakt. Bd. 23) and others have shown the presence of plague bacilli in the intestines of flies, fleas, bugs, mosquitoes, ants and moths.

These results, some of which I have verified, certainly show the frequent presence of plague bacilli and other micro-organisms in the intestines of insects. Given, however, this fact, an important point to consider is what are their chances of spreading the disease for which they are responsible.

According to HANKIN (Cent. f. Bakt. Bd. 22) plague bacilli remain virulent for some considerable time in the intestines of ants. In the intestines of flies they remain virulent for 48 hours or more. In the intestines of bugs and fleas plague bacilli die rapidly. Similar results have been published by NUTTALL, SIMOND, and others who showed in addition, that in some cases, such micro-organisms have their virulence altered by such a passage through the alimentary canal of an insect. *In the case of flies, plague bacilli pass through the intestine uninjured.* In the case of bugs and fleas, the virulence of plague bacilli would appear to be lowered by such a passage.

With so little time at my disposal this part of the research had not received that amount of attention which it merits. The conclusions drawn by different scientists in regard to the subject are so varied that at present one must accept the results with reserve. So far as we know, some micro-organisms pass through the intestines of insects uninjured, others have their virulence diminished, while, according to one investigator CAO (Ufficiale sanitario, 1898) some non-pathogenic bacteria gain virulence on passing through thr alimentary canal of certain insects, *e. g.*, the Periplaneta orientalis. The latter observation, however, is an isolated one. Again it must be borne in mind, that different insects will react to different bacteria and infections in different ways.

In regard to the question of the vitality of micro-organisms on or in the body of insects, we must always take into account the effects of drying and sunlight on the one hand, and the action of chemical and bacterial products in the alimentary canal on the other hand.

II. *The Mechanism of the Infection.*—That diseases are communicated to man through the agency of insects is a fact established beyond dispute. The investigations of the last decade have revealed to us the important role played by insects in the dissemination of certain diseases. The mosquito and its relation to malaria and filiariasis and other diseases may be instanced, and year by year there is being added to our knowledge an accumulation of facts bearing upon the insectiverous spread of disease. So far these investigations are limited to diseases which are occasioned by parasites of a certain degree of organisation, parasites which pass through a definite cycle of changes during their development, either in the body of the host or intermediate host. These changes are complicated and show that in these parasites we have to deal with an organism which, in its mode of development and conditions of life, is something very different from germs of the type of cocci, bacteria, or vibrios. The latter are organisms of an altogether different type from the plasmodium malariæ. Convincing observations are wanting at present to prove the direct transference by an insect of any coccus, bacterium or vibrio which is the causal agent of a definite specific infectious disease, to the tissues of man. In the case of malaria or filiariasis there exists a special mechanism through which the parasite gains the human body but no such process is indicated in regard to the dissemination of pathogenic microbes by insects. *It would rather appear from the standpoint of our present knowledge that the direct inoculation of the human subject with pathogenic parasites by means of an insect, is limited to a class of organism considerably removed and higher in the scale of development than those simple cocci, bacteria, or vibrios which are the causal agents of so many infectious diseases.* Taking up the question of the mechanism of infection at this point, we find numerous observations in literature in regard to the direct connection between insects and disease. The majority of the examples cited in literature are isolated observations, and their importance from a modern epidemiological point of view is extremely doubtful. For instance, gnats were held responsible for the occurrence of abscesses, bugs for relapsing fever, mosquitoes for leprosy, and ants, emmets and other insects for plague.

It is obvious, however, that in order to grasp the mechanism of infection fully, one must distinguish between insects which are able to make a wound and those which are not. The latter may be left out of consideration for the present. The mechanism of infection by non-suctorial insects will be discussed under a separate heading. Such insects should they harbour pathogenic bacteria, can only become dangerous in an indirect way.

(*a.*) *Suctorial Insects.*—Numerous species of insects suck the blood of man and animals. Each country has its collection of such animals and it is quite out of the province of the present manuscript to deal with the actual species of insects biting man. Mosquitoes, fleas, bugs, gnats, ants, etc. are found all over the world, and if suctorial insects are the means of spreading infectious diseases directly by their bite, it becomes a difficult problem to sift out those which are most culpable. Mosquitoes may be dismissed in a sentence. I have examined numerous mosquitoes, caught in the Kennedy Town Plague Hospital, during an epidemic of plague and at a time when the wards were practically full of cases of plague, but in every instance I have failed to find the B. pestis. Many of the mosquitoes were caught under the nets of beds containing plague patients, yet, although these had sucked a considerable quantity of blood from the patient, no plague bacilli could be found. Emulsions of these mosquitoes were injected into rats with a negative result. It will be well to mention here, that even although plague bacilli had been found in their stomachs, it is difficult to explain how they could convey the infection to another individual in the absence of some special mechanism. Allowing the fæces of the mosquito to contain plague bacilli, then, should the insect defacate on the individual's skin during the act of sucking, the subsequent scratching by the individual might possibly inoculate the puncture wound. Such an infection, however, must be regarded as distinctly secondary, through a wound in the skin and not directly due to the action of the insect itself. Its occurrence must be rare. A puncture wound, such as made by a suctorial insect, becomes closed almost immediately after its infliction owing to the reactive changes which occur at once around the wound.

My absence to find plague bacilli in mosquitoes is in accordance with the views already expressed by the members of the Austrian and German Plague Commissions. Again if mosquitoes played an important role in the direct dissemination of plague infection, doctors, nurses, and attendants in our Plague Hospital, where such insects abound, would have little chance of escaping infection.

Fleas.—These insects have been the objects of much investigation and particularly in regard to role played by them in the spread of plague. As a result of this, the genus has been thoroughly worked out and the various individual species tested for their plague carrying powers. It is asserted by Bathelhuer that at least 60 to 80 different species of fleas exist and that each species is restricted to a definite animal. That is to say we have rat fleas, dog fleas, etc. These fleas are not supposed to bite man. According to Galli Valerio (Cent. f. Bakt. Bd. 27, 1900) the human flea is different morphologically from animal fleas, especially the rat flea.

The human flea, however, is cosmopolitan. It prefers the blood of man, but in the absence of that, it can accomodate itself and feed upon the blood of other animals. Again, it must be remembered that there undoubtedly exists a predisposition on the part of certain individuals to fleas. Certain human beings are almost immune to fleas, *e.g.*, fleas do not bite them; other persons are decidedly susceptible, and are attacked and bitten whenever an opportunity presents itself. Probably the same obtains in regard to different animal species.

During the past few years, in fact ever since the rat theory of the spread of plague became prominent, many experiments have been undertaken in order to determine whether plague infection in the rat is conveyed to man by way of rat fleas. The experimental evidence which has been obtained is so far of a most unsatisfactory nature. Simond (Annal. Pasteur, Bd. 12, 1898), who has given a great deal of attention to this subject, came to the conclusion that Indian rat fleas bite man and that rat fleas spread plague from one rat to another and also to the human species.

At this point it will be well to remember that the dead bodies of rats while still warm, are infested with fleas, but when the body becomes cold and stiff, these insects migrate. So that so far as fleas are concerned, the dead bodies of rats

cannot be regarded as dangerous. Galli Valerio (Cent. f. Bakt. Bd. 27), Nuttall (Hyd. Rundschau Bd. 9, 1899), Kolle (Deut. Med. Wochenschr, 1902) and others have shown that Simond's conclusions go too far and Pfeiffer holds that the experiments conducted by Simonds do not justify so conclusive an opinion, and notes the fact that in India insects in general were found to be of no great epidemiological importance.

Without going deeper into detail, it may be said that the general results obtained by direct observation and experiment go to show that *fleas play an unimportant role in the direct spread of plague.* Experiments in regard to this question have also been carried out in Hongkong. In 1902 Professor Simpson and myself endeavoured to procure the infection of healthy rats and monkeys by plague infected rat fleas. The results were entirely negative. The details of these experiments are given in Professer Simpson's Plague Report, page 56.

Again in connection with my duties in supervising the routine examination of rats, plague or otherwise, I have frequently had occasion to examine the nature of the vermin found on these animals. I have had these fleas on my hands and arms, giving them an opportunity to bite, but so far they have refused my blood.

I am strongly of the opinion that fleas are restricted, as Gaertner, Kolle, Galli-Valerio, Nuttall and others assert, to definite animal species and this coupled with the negative results obtained by experiment, is good established evidence, that *plague infected fleas are of no practical importance in regard to the spread of plague.*

Ashburton Thompson, in his Plague Report for 1902, reports as follows on rat fleas:—"It is found to be well founded that the species of fleas which infest rats seem, on the one hand, not to infest man, but, on the other, to have no repugnance to him."

In general, the production of plague infection in animals by the bite of plague infected fleas is a rarity. Fleas may leave the plague infected body, human or otherwise, and bite healthy subjects, but the question is, do they infect the latter? The general experience in other countries points to a negative reply. Even although the flea contains plague bacilli in its stomach or intestines, there is so far no satisfactory evidence of any danger through the puncture bite of such an insect.

Bugs.—The ordinary bed bug—Cimex lectularis—has been held responsible for the spread of plague, but the evidence upon which the conclusion is based is not, on careful analysis, of a convincing nature. Such insects may bite and suck the blood of a plague infected individual. It does not necessarily follow that such bugs are able to communicate the disease directly to other animals or man. The experimental evidence in the case of these insects is almost entirely negative. The most important experimental results were obtained by Nuttall (John Hopkins Hospital Reports, viii. 1899). Twenty-two bugs were allowed to suck the blood of a mouse dying of plague. The bugs were immediately placed on four healthy mice. None of these mice contracted plague.

Again experiments were made along the same lines with anthrax, chicken cholera, and mouse septicæmia, but although mice are extremely susceptible to these diseases, none contracted the diseases after being bitten severely with the infected bugs. I had several opportunites of examining numbers of bugs bacteriologically for the presence of plague bacilli. These insects were usually obtained from houses in which cases of human plague had occurred. In many instances plague bacilli were found after emulsions of the animals had been made and cultures and experimental tests applied. Further details are unnecessary as *the same remarks apply to bugs as already detailed under the subject of fleas.*

Pediculi.—A number of these insects was obtained from plague patients in the Kennedy Town Hospital. A considerable number was examined but a negative result was obtained. *These animals would not appear to play a great part in the spread of plague.*

(b.) Non-suctorial Insects.—A considerable number of details in regard to this class of insect has already been given. The occurrence of pathogenic bacteria on the body surfaces of flies, cockroaches, etc., has been referred to on several occasions. Plague bacilli were found by myself on the surface of flies and the result confirmed by animal experiment. The observations in regard to the spread

of plague by cockroaches is of the greatest importance and the role played by these animals, flies and other non-suctorial insects in the indirect spread of plague infection is one which, from a prophylactic point of view, must never be forgotten.

It is the indirect spread of plague infection which insects accomplish. From what has already been said, it will be evident that suctorial insects are not of such importance as some observers would argue. The indirect spread of plague by insects is requiring of more investigation. By flies, cockroaches, etc , there is no saying how far and how extensive the infection may have reached. All varieties of food stuffs, fruit, clothing, household articles and general utensils are liable to such contamination. Flies, etc. may obtain the specific agents from a variety of sources, *e.g.*, human secretions excretions, rats, or other infected articles, and subsequently transport these germs of plague to any object upon which they may chance to alight.

III.—Relations between insect species and animal species.—These relations have already been discussed, particularly under the subject of fleas Further investigation is necessary but the evidence already brought forward is mostly in favour of definite insect species feeding upon definite animal species. So far as I know the subject has only been investigated in regard to the genus flea. The question as affecting bugs, lice, etc., has still to be unravelled.

IV.—Relation between infected clothing and insects.—This is important if we grant that the wounds made in the skin of man by suctorial insects are capable of being secondarily infected through scratching and infected clothing Reliable instances of the occurrence of such a mode of infection in plague have so far not been obtained. The scratching of the skin subsequent to an insect bite may produce secondary inflammations. These are caused by the presence of pyogenic cocci lying deeply in the folds and glandular ducts of the skin. In my opinion, however, it is scarcely possible, or or at least it must be extremely rare, to trace the avenue of infection to such a source.

V.—The Infection of food by insects.—This appears to me to be *the most important role played by insects in the dissemination of plague infection.* The method is an indirect one. The question as to its occurrence has already been muted, particularly in regard to flies, cockroaches, etc., and in Hongkong where insects of all kinds become in themselves pestiferous during certain seasons of the year, including the epidemic plague season, it appears to me not improbable in the light of my results and others, that this part played by insects is dangerous to public health to an extreme degree. That infectious diseases may be spread in this way has already been proved. Flies are undoubtedly carriers of infection from place to place and are known to be excellent distributers of all varieties of micro-organisms. The spread of typhoid fever by flies in the South African Forces, described by ZUM BUSCH and others, and the results obtained by the United States Army Medical Commission in the Spanish American War in regard to enteric fever, are excellent examples of such a spread of infection by insects. Again the experimentally proved occurrence of the infection of food by flies which had previously been in contact with cholera dejecta is another instance of such a process.

The infection of food by insects would appear to be a commoner mode of spread of the disease than is generally believed. As has already been mentioned POUND'S observation of the transmission of plague infection to food by the cockroach is a noteworthy point in this connection. My own experiments showed the presence of plague bacilli in cockroaches, and, as will be seen, plague bacilli have been found in food, namely, rice. It is not improbable that some connection exists between these. At the same time food may become infected through other agencies, namely, contact with plague infected material of varied nature and the secretions and excretions of plague infected man and animals.

My own observations convince me that such a method of transmission of the disease is extremely common. The infection of food and household utensils would appear to be the most important role played by insects in the spread of plague. The experiments made by Professor SIMPSON and myself in this Colony during 1902, point to the importance which must be attached to food as a factor to be reckoned with by those actively engaged in prosecuting the methods for the suppression and prevention of the disease.

WILLIAM HUNTER.

BACTERIOLOGICAL EXAMINATION OF INSECTS.

No.	Date of Examination.	Name of Insect.	No. Examined.	Address.	Result of Examintion.
1	27th July, 1903.	Mosquito—Culex.	3	Kennedy Town Hospital. Caught inside net covering a patient suffering from plague.	No plague bacilli found.
2	28th July, 1903.	Do.	4	Do.	Do.
3	30th July, 1903.	Do.	6	Do.	Do.
4	1st July, 1903.	Flies—Musca domestica.	30	Kennedy Town Hospital. Caught in wards full of plague patients.	75 % of the flies examined showed the presence of plague bacilli.
5	3rd July, 1093.	Do.	20	Do.	45 % do.
6	8th August, 1903.	Pediculi.	20-30	Kennedy Town Hospital. Caught on patients suffering from plague.	No plague bacilli found.
7	10th September, 1903.	Do.	10-20	Do.	Do.
8	8th July, 1903.	Bugs—probably Cimex lectularis.	4	103 Third Street—House in which 2 cases of plague occurred.	Do.
9	10th July, 1903.	Do.	20-30	From different houses in Third Street where plague cases occurred.	10 % infected with plague bacilli.
10	24th May, 1903.	Fleas.	About 20	No. 4 Sheung Fung Lane, where several cases of plague occurred.	No plague bacilli found.
11	25th May, 1903.	Bugs—Same species as before.	About 10	Do.	Do.
12	28th May, 1903.	Flies.	15-20	Do.	Do.
13	10th June, 1903.	Spider.	1	Do.	Do.
14	10th June, 1903.	Bugs—Second instalment.	10-15	Do.	Do.
15	21st June, 1903.	Bugs.	15-20	109 Second Street 1st floor where 2 cases of plague occurred.	Do.
16	21st June, 1903.	Do.	10-12	109 Second Street from ground floor.	Plague bacilli found in a considerable number.
17	9th July, 1903.	Cockroaches.	About 10	Stall 88, Central Market.	Several found plague infected.
18	14th July, 1903.	Do.	5	Central Market.	One found plague infected.

WILLIAM HUNTER.

The Importance of Food in Plague.

The importance of food in plague appears to have attracted but scant attention. Apart from the researches of WILM, an examination of the literature on plague gives us no idea as to the question whether food is an important factor to be reckoned with in dealing with the prophylaxis of the disease. Soon after my arrival in the Colony, I conducted, along with Professor SIMPSON, certain experiments in regard to the susceptibility of various animals to plague infection. The general result of these experiments was, that the most certain method of producing plague infection in an animal supposed to be resistant was by feeding with plague infected material. Having elicited this fact, I set about an enquiry as to the possibility of the infection in plague being communicated to man by way of the food. I had already satisfied myself as to the existence of profund pathological changes in the stomach and intestines of individuals dead from the disease, and of the presence during the initial phase of plague of marked gastro-intestinal phenomena. The only point which appeared to me to complete the evidence was the possibility of demonstrating the plague bacillus in food stuffs. Accordingly a large number of samples of food was submitted to me for bacteriological examination. Thirty-two different specimens were systematically tested, and the results obtained are chronicled in the attached table. It seemed a pity that a larger number was not examined. This, however, was found impossible owing to the existence of numerous other duties connected with the epidemic of plague which was raging at the time. I trust opportunity will be found to investigate the question further. The present results are to be regarded as preliminary. They are of sufficient importance, however, to justify their being recorded and add an important link to the chain of evidence in favour of the gastro-intestinal avenue of infection in plague.

The diet of the Chinese consists mainly of rice with the addition of pork, fish, fowls, etc. These are the staple articles of diet. The notion that mice, rats, dogs, cats are common articles of diet of the Chinese would appear to be erroneous. DYER BALL in his book on "Things Chinese" notes that rats, dogs and cats are occasionally consumed, but only by the lowest class of Chinese. The eating of dead rats would be of great importance in regard to the spread of plague. In Canton dried rats are exposed for sale in the shops. From our experience in Hongkong it is possible to convey plague to swine, fowls and other rats, etc., by feeding them on the dead bodies or individual organs of a plague infected rat.

Further, the coolie or pauper class Chinese supply the large number of cases during an epidemic of plague.

The methods of bacteriological examination, employed by me to isolate the various micro-organisms from the different samples of food are briefly the following:—

Small quantities of the particular food to be examined was thoroughly soaked and rubbed up in sterilised physiological saline solution, or in beef tea. By this means the micro-organisms present were isolated as far as possible from the solid material. Plate cultivations were made from the solution before and after strong centrifugalisation. Stroke cultures on agar and blood serum tubes were also inoculated. All the culture were kept at 35° C. The colonies found present were isolated on fresh nutrient media and biological tests and experiments made.

Centrifugalised deposits were also inoculated into animals, *e.g.*, the rat, and positive results obtained. This method is most inconstant in its results owing to the presence of numerous other bacteria.

All the animals experimented with were previously tested for their condition of health. Some of the samples gave such large numbers of bacteria present, that it was impossible to determine their exact bacteriology.

Again one sample of rice when given to rats, set up plague in those animals. Further, I have infected rice artificially with beef tea cultures of plague, and obtained positive results on feeding rats with the mixture.

Guinea pigs also give similar results.

All foods in the natural condition contain many species of micro-organisms. The majority of these are harmless non-pathogenic germs. They consist mostly of cocci and bacteria, accompanied by moulds of several species. My result in regard to the general bacteriology of foods is in harmony with those obtained by other observers. My object, however, in carrying out this research, being the determination of the presence or absence of the plague virus in foods, special attention was paid to the latter. My research was crowned with success by *the discovery of plague bacilli in considerable numbers in rice.* Repeated examination of this food was made, and the result was always positive. *The rice found infected was the cheapest and most inferior quality of the cereal.* This quality is used as food by the majority of the poorer class of Chinese. If reference be made to the attached table it will be found that the samples Nos. 6 and 7 were contaminated with the B. pestis. There was no doubt about the micro-organism. Its presence was confirmed by experiments on rats.

Sample No. 15 must be regarded as suspicious. Micro-organisms, morphologically and biologically like the B. pestis, were found. The results of experiment were negative. One is not justified, however, in declaring such a sample to be plague infected in the absence of positive experimental evidence.

Rice is the only food which I found infected. Further investigation would probably have led to other positive results, but the extension of the enquiry was impossible at the time. The discovery of the plague bacillus in food is not new. Gladin (Cent. f. Bakt. Bd. 24, 1898) kept the B. pestis alive for more than three weeks in milk, albumin, potatoes, plums, apples, bread, etc. This is of great importance, in my opinion, if we consider *the large quantity of fruit consumed in raw state by the natives and Europeans in Hongkong.* The question of the presence of infected fruit in our local markets, and the frequent consumption of fruit in the market by Europeans and natives alike must not be forgotten in tracing the sources of plague infection.

Again, the results of Stadler (Arch. f. Hygiene Bd. 35, 1889) are interesting. This observer found plague bacilli alive and virulent in pickled flesh, even after the process of pickling had been carried out for 16 days. So far as Hongkong is concerned this is important. It is known that pork is the chief meat of the Chinese in the south, so much so that the word meat is often used to mean pork. Further it is probable that the pickling or salting as done by the Chinese is not carried out in a scientific manner or without the admixture of a considerable amount of extraneous dirt.

The results obtained by Hankin (Das Österr, Sanitätswesen, 1897) are similar to those obtained by myself. This investigator found that *the length of life of the plague bacillus on grain was considerable.*

Food as an important vehicle for the conveyance of infection, has been recognised for some considerable time. To show its importance in disease, it is only necessary to mention Typhoid fever, Cholera and Botulism.

Foods may become infected with bacteria in several ways.

(1.) Saprophytes are normally present in the food. Under ordinary conditions they are harmless. Occasionally, however, they take on a rapid growth, resulting in the production of considerable quantities of poisonous matter which excites disease. A good example is the presence of Flügge's peptonising bacteria in milk (Zeit. f. Hyg. Bd. 17, 1895).

(2.) Pathogenic bacteria may be conveyed to man through flesh or fluids obtained from sick animals. A well known example is tuberculosis. Such a thing has been proved to occur in experimental plague. It is easy to infect almost any animal by feeding it with pieces of plague infected human spleens or blood. There is no reason to doubt the reverse of this experiment.

(3.) The causal agents of the most important infectious diseases in man frequently reach the food. These agents are conveyed to the food by man himself and also by animals. By man owing to his carelessness and filthy habits—and this is probably a factor of great importance amongst the Chinese; by animals such as rats, mice, cockroaches, flies, etc., which either by contact or by the infected condition of their secretions and excretions, deposit the specific germs on the article of diet.

Such methods as indicated in Nos. 2 and 3 probably play a part in plague, that indicated in No. 3 cannot be overlooked and is probably one of the great means of the spread of plague.

The opportunities afforded to such infected food as rice, in order to spread the disease are greatly enhanced by the conditions under which the Chinese live and prepare their food for consumption.

It may be argued that supposing such foods are infected, there would be little chance of the conveyance of the infection to man owing to the limited length of life of the B. pestis outside the body. It is true that the plague bacillus does not thrive extra-corporeally, but nevertheless, the organism shows a considerable resistance to the action of other saprophytes which tend to overgrow it. Its resistance to the influences of putrefaction is known, and although restrained in its power of multiplication, it is able to exist in a living virulent condition for some time. The length of time is influenced greatly by the temperature. The higher the temperature, the shorter is the life of the plague bacillus.

WILLIAM HUNTER.

SAMPLES OF FOOD—BACTERIOLOGICAL EXAMINATION.

No.	Date of Examination.	Nature of Sample.	Address of Sample.	Result of Examination.
1	29th June, 1903.	Dried Mussels.	65 First Street.	No plague bacilli found. Large numbers of other micro-organisms present more particularly staphylococcus pyogenes albus, and aureus, bacillus vulgatus, bacillus coli.
2	29th June, 1903.	Shrimps.	65 First Street.	No plague bacilli found. Other micro-organisms abundant, namely, cocci, rod shaped bacteria, aspergilli.
3	29th June, 1903.	Mushrooms.	65 First Street.	No plague bacilli found. Mucor mucedo and racemosus in great abundance. Cocci and bacteria also present in great variety.
4	29th June, 1903.	Bean sprouts.	65 First Street.	No plague bacilli found. Moulds present in great abundance.
5	29th June, 1903.	Rice, No. 3 Quality.	67 First Street.	No plague bacilli found. In addition to large quantities of mucor mucedo and erectus, a large bacterium with a tendency to form chains was constantly present.
6	29th June, 1903.	Rice, No. 4 Quality.	67 First Street.	Plague bacilli present in large numbers. Moulds and bacillus coli abundant. *Plague bacilli confirmed by animal experiment.*
7	30th June, 1903.	Rice, No. 4 Quality, [Second Sample.]	67 First Street.	*Result as in No. 6. Plague bacilli present.*
8	30th June, 1903.	Scrapings from a baking board.	No address given.	No plague bacilli found. Moulds as mucor racemosus, aspergillus nidulans and penicillium glaucum present. Yeasts also found. Bacillus coli and other bacteria present.
9	30th June, 1903.	Bean curd.	No address given.	Hoards of different micro-organisms found in the mass. No plague bacilli found. Bacillus coli in great numbers.
10	30th June, 1903.	Salted vegetable.	No address given.	No plague bacilli found. Bacillus protens and coli present.
11	3rd July, 1903.	Rice, No. 4 Quality.	71 Third Street.	No plague bacilli found. Hoards of micro-organisms present including B. coli.
12	3rd July, 1903.	Rice, No. 4 Quality.	392 Des Vœux Road.	No plague bacilli found. Organisms belonging to the Hay bacillus and coli groups present in large numbers.
13	3rd July, 1903.	Pea nuts.	56 Second Street.	No plague bacilli found. Moulds present in great abundance.

SAMPLES OF FOOD—BACTERIOLOGICAL EXAMINATION,—*Continued.*

No.	Date of Examination.	Nature of Sample.	Address of Sample.	Result of Examination.
14	4th July, 1903.	Rice, No. 4. Quality.	133 Bonham Strand.	No plague bacilli found. Organisms belonging to coli group present.
15	4th July, 1903.	Rice, No. 4 Quality.	68 Second Street.	*Micro-organisms resembling B. pestis morphologically and culturally.* Experimental evidence negative. Hoards of other bacteria present.
16	11th July, 1903.	Flour.	41 Nullah Lane.	No plague bacilli found. Moulds present in addition to other micro-organisms.
17	11th July, 1903.	Flour.	92 Queen's Road East.	Bacillus subtilus and other organisms of the same group present in large numbers. No plague bacilli found.
18	11th July, 1903.	Vermicelli.	61 Nullah Lane	Similar to No. 17.
19	11th July, 1903.	Vermicelli.	347 Queen's Road East.	Similar to No. 17. B. coli present in large numbers.
20	11th July, 1903.	Macaroni.	Stall 48 Central Market.	No plague bacilli found. Organisms belonging to Hay bacillus group and B. coli present.
21	8th August, 1903.	Paddy.	Stall 61 Central Market.	Similar to No. 20.
21	8th August, 1903.	Bran.	Stall 61 Central Market.	Similar to No. 20.
22	8th August, 1903.	Paddy.	Stalls 72 & 87 Central Market.	Similar to No. 20.
23	10th August, 1903.	Bran.	Stall 72 Central Market.	Similar to No. 20.
24	10th August, 1903.	Bran.	7 Jubilee Street.	Similar to No. 20.
25	10th August, 1903.	Bran.	Stall 82 Central Market.	Similar to No. 20.
26	10th August, 1903.	Paddy.	Stall 82 Central Market.	Similar to No. 20.
27	20th August, 1903.	Pat Choy.	Stall 84 Western Market.	No plague bacilli found.
28	20th August, 1903.	Kai Choy.	Stall 84 Western Market.	No plague bacilli found.
29	25th August, 1903.	Ling Ngau.	Stall 84 Western Market.	No plague bacilli found.
30	25th August, 1903.	One Fish.	Stall 137 Western Market.	No plague bacilli found.
31	28th August, 1903.	Roast Pork.	Western Market.	No plague bacilli found.
32	28th August, 1903.	Vegetables, (assorted).	Western Market.	No plague bacilli found.

WILLIAM HUNTER.

The Principles of General Prophylaxis.

The principle of rational prophylaxis and combative efforts against all infectious diseases consists in measures directed against the causal agents of these diseases. Such measures as are to be of value in eradicating a disease like plague, have to be directed straight to the root of the evil, namely, to the destruction of its causal agent—the now well known Bacillus pestis. Without a knowledge of the agent at work in the production of the disease, our efforts at a rational prophylaxis would fall far short of the necessary standard.

Bound up closely with this knowledge of the specific causative agent, are other factors which are of importance, namely, a knowledge of the biological characteristics of the micro-organism, of the powers possessed by the organism to produce the disease, of the question of immunity, and of the necessary conditions of life for the maintenance of the bacillus inside and outside the body.

A knowledge of the morphological characters of the plague bacillus is of the highest importance in a general sense, especially for purposes of diagnosis and an early recognition of the disease, but so far as prophylactic measures are concerned, these characteristics are of relatively little importance.

In order that such an organism as the Bacillus pestis may produce the symptom-complex of plague, certain conditions must be present. In the first place, there must be a source of infection producing the bacillus and supplying it in a living and virulent condition. Without such it is inconceivable for the disease to break out. Epidemiology has established the fact, that exotics as plague which are not endemic in a country, never have an autochthonus origin, but are always introduced from without. The most important source of infection is of course an individual suffering from the disease, and more particularly the secretions and excretions from his body. Again, so called latent cases are of importance, in which the individual appears in good health, yet harbours enormous numbers of the specific germs and scatters them about him. This sort of thing is well known in the case of cholera and would appear to hold good for plague (*vide* cases of accidental death in which the B. pestis has been found in the blood and internal organs).

Again, a source of infection and one of the highest importance so far as plague is concerned, is the occurrence of the disease in animals. Rats suffering from plague, constitute probably the most important element of danger to man. These vermin are known to harbour plague bacilli for long periods of time. The disease is often chronic in them and the occurrence of latency in rat plague cannot be disregarded in the light of the most modern research. Again, other animals, as cats, fowls, calves, sheep, pigs, etc., are susceptible to plague infection, and become thereby elements of danger to the general public who frequently come into close contact with them.

The question as to the importance of water, soil, air, etc., in regard to the spread of plague may be discarded to a great extent. The danger attached to these elements would appear to have been grossly over-estimated. Food as a source of the disease has already been dwelt upon under a separate heading. The contamination of food by vermin, insects, the handling by infected persons of articles, etc., is a subject requiring the most earnest consideration on the part of Sanitary authorities. My own researches appear to show that plague to a great extent is a disease originating in the alimentary canal, the conveyance of the infection being effected through plague infected articles of diet.

The avenues of infection in plague may be divided into direct and indirect ways. Direct infection is mainly occasioned through wounds and direct inoculation. This mode would not appear to play an important part in the spread of the disease.

Indirect infection, on the other hand, is of the highest importance. The presence of innumerable plague infected rats, scattering broadcast hoards of plague bacillus through their secretions and excretions, rendering possible the gross infection of food, water, etc., constitutes an element of great danger to public health. Again the clothing and linen of plague patients may be the means of conveying the infection to the extreme ends of the earth.

The secretions and excretions of plague infected individuals themselves offer innumerable chances for indirect infection. The so called "Drop Infection," with the exception of severe pneumonic types of epidemics, would appear to play but a small part in the spread of the disease.

The links in the chain of infection in plague may be named the following:—

(1.) The source of infection.
(2.) The method of transportation.
(3.) The gates of entrance.
(4.) The amount of the virus.
(5.) The quality of the virus.
(6.) The susceptibility of the individual.

If one of these links is missing there is no chance of the disease breaking out. *A priori* it is of little consequence for prophylaxis what link in the chain is attacked, provided the causative agent in the particular link is effectively combated. For general purposes, however, it would seem best to attack each link in the chain simultaneously, provided an opportunity presents itself.

The international arrangements and quarantine regulations, regarding the prevention of an exotic disease like plague, have become extremely complicated and rigid within the past few years.

Exotic diseases, in general, are not like measles, tuberculosis, venereal diseases, etc., which are endemic; they *are always introduced into a country*.

They are never of autochthonous origin. Another point of interest here is that these exotic diseases, namely, plague, cholera, and probably yellow fever, are not only introduced into a country, but the method of introduction or the avenue of infection is almost always by way of the sea. *Maritime commerce is therefore largely responsible for the spread of plague*, and the defensive measures adopted against these diseases have much in common. The measures directed against the spread of cholera are almost identical with those laid down to combat the introduction of plague.

Within recent years, another channel of infection has been opened up for the spread of the disease. *Railways* are being constructed in all parts of the Continents of Europe and Asia, and *will constitute an element of even greater danger than the sea*. The disease will, in this way, be rapidly transported from one end of the world to the other, and all the skill and vigilance of sanitary authorities will be required for the prevention of its introduction. The construction of the Trans-Siberian, the Bagdad, the Russo-Indian, the Russo-Persian as well as numerous railways in plague stricken Southern China will add to the already over-taxed energies of sanitary authorities and public bodies. The present day regulations and international quarantine arrangements in order to insure a trustworthy prophylaxis are widely known to all those interested in the prevention of exotic diseases.

What remains, is to consider these quarantine measures critically and judge whether such regulations and arrangements in their present form have fulfilled our hopes and insured us freedom from plague or other similar diseases.

The answer must be in the negative.

In fact, one may go further and apart from certain exceptions, assert that with our present state of knowledge, *we possess no means of being absolutely certain as to the prevention of the introduction of plague into any particular country or city.*

The grounds for such a sweeping statement are as follows: The very essence of quarantine directs its energies in the first place to plague patients, in the second place to those individuals in whom the disease is inoculating and thirdly to the possibility of indirect infection through merchandise and personal effects. However, our ever advancing knowledge of plague has shown, only within the last few years, that two other factors, hitherto disregarded, have a very important bearing on the whole question.

These are the knowledge of *the existence of latent cases of plague, and the predominant role played by rats.*

Latency in plague does occur. There is no reason why it should not. It is now a well recognised fact that pathogenic micro-organisms may be present on the external and internal surfaces of the body, as well as in the internal organs without calling forth manifest symptons of disease.

According to GOTSCHLICH, such cases of latency may be divided into three categories:—

(1.) Latency during convalescence.
(2.) Latency in healthy individuals.
(3.) Latency with accompanying trivial symptoms, such as one finds in the initial stages of many infectious diseases.

It has now been proved that individuals convalescent from plague may be sources of great danger to public health. Plague bacilli may be discharged from their bodies for some considerable time after their recovery from the disease, and the bacilli discharged are alive and virulent, and capable of setting up the disease in other individuals or animals. Dating from the commencement of the disease, GOTSCHLICH and others have found plague bacilli in the excretions for 70-80 days or even longer. The sputum is also known to harbour plague bacilli for a long time even after recovery.

So far as I know quarantine regulations take no cognisance of such cases of latency. Success in the extermination of rats on board ship is a much wished for victory. At the present time no absolute guarantee of their having been got rid of in any ship can be given with the most modern means at our disposal for their destruction.

Within the past few years there exists plenty of proof of the introduction of plague into a sea-port by plague infected ship rats. Added to these questions, namely, the occurrence of latency in plague, and the role played by rats, must be added another, equally important, the difficulty or even impossibility of locating sufficiently early the boundary of the plague infected area or what is known as *the "circonscription territorialle contaminée."*

Summing up this criticism of the present day quarantine efforts at prophylaxis, it may be said that such regulations have not come up to what we expected of them, and that *the frequently one-sided and rigorous measures adopted stand in no relation to the damage inflicted on commerce and international relations.*

A reform of the present quarantine measures would appear to be necessary. The system requires to be limited. As GOTSCHLICH has it, the system should apply, in ordinary international commerce, to actual infected and suspected ships. There should be no rigid rules and regulations or standing orders for the Public Health Officer. Competent officers should be left to a certain extent to the guidance of their own initiative, according to the nature of the circumstances which may be before them.

All this becomes evident to those who have had much experience of epidemics of plague. To them, it is of the greatest importance to know the particular variety of the disease before them. They must apply the measures at their disposal according to whether simple septic cases are prevalent or whether they have to deal with the deadly primary pneumonic type of the disorder.

It is of interest to note that measures in regard to these various points have been recommended by the members of the recent Conference in Venice. The detailed examination of all incoming ships during plague epidemics is a most important duty and a further excellent plan would be the continual supervision of all ships in the port as recommended by GAFFKY.

Again, the control of the health of the ship during voyage is necessary. In connection with this two recommedations might be made. *Firstly there is urgent need for better trained ship doctors, and secondly the authority exercised by ship doctors ought to be strengthened.*

Further, *the medical examination of passengers and crews of out-going ships* and *the control over cargo and merchandise ought to be rigorously prosecuted.*

The examination of merchandise should never be neglected, if there is any suspicion of plague. There is the possibility of its infection through plague infected rats to be borne in mind. Cases of such have been reported during the past few years. According to KOSSEL and NOCHT, in Hamburg merchant ships arrived from plague infected ports. No cases of plague in man had occurred on board. The cargoes were discharged and with them were found numerous dead rats which had died of plague. In such cases contact of the ship's rats with those on shore must be avoided, and those engaged in discharging the cargo, ought to be placed under medical supervision.

The measures against rats on board are now universally adopted. The destruction of rats on board ship is a matter of great difficulty. The use according to the fire extinguishing and disinfecting system of *an apparatus like Clayton's is not always satisfactory.*

In summing up, therefore, the principles involved in general prophylactic measures against plague, one must strongly advocate, the following :—

(1.) The limitation as far as possible of actual quarantine.
(2.) The extension of the system of revision.
(3.) Strong measures against rats.
(4.) The evidence of all unnecessary dogmatic rules and standing orders.
(5.) The individual treatment of each case according to its merits.
(6.) The employment of competent ship doctors.
(7.) The employment of skilled port officers well versed in quarantine matters. These officers, in order to overcome the many duties of their office, must devote the whole of their time to this work. Otherwise the measures at their disposal may be carried out in a desultory fashion.

WILLIAM HUNTER.

The Principles of Special Prophylaxis.

Viewed from an epidemiological point of view plague is found to occupy a place amongst infectious diseases peculiar to itself, this is evidenced by the fact that there exists for the spread of the disease two great avenues of infection. Indeed approaching the question from a strictly public health standpoint, there exist two entirely different types of plague epidemics, namely :—

(1.) Epidemics caused by plague infected rats.
(2.) Epidemics caused by plague infected individuals.

The first is what we commonly meet with in Hongkong, namely, septicæmic plague with bubonic and pneumonic manifestations.

The second is rarely found in Hongkong. It is what is known as primary pneumonic plague. This form was frequently the cause of enormous epidemics during past centuries. It would appear to be less frequently met with now-a-days It is the most dreaded form of plague.

Septicæmic plague in its various forms depends upon a rat epizootic which is now generally known as "Rat Plague." Man becomes infected either by direct contact with infected rats or by indirect contact, the virus being conveyed to him through the agency of infected habitations, ships, goods, etc., upon which rats scatter their secretions and excretions. Infection by direct contact would appear to be rare. Infection by indirect contact is, in my opinion, the usual mode of conveyance of the B. pestis from the rat to man.

At the same time the conveyance of plague infection from man to man or from man to rat by way of infected secretions and excretions must not be lost sight of.

The transference of infection by way of suctorial insects would appear to be of no practical significance. Bubonic plague is held by many people to be of no importance in regard to the spread of infection. From my researches, however, this appears to be only partially true. The discharges from the buboes may be regarded as not dangerous to public health as the plague bacilli originally present

become replaced by ordinary pyogenic cocci. It must be remembered that the bubonic variety of plague is only a manifestation of the septicaemic disease. The organisms are present in the blood and multiply in the blood, and are scattered broadcast by such infected individuals through their excretions and secretions. Therefore such types of plague are not to be treated lightly. In my opinion, each of the varieties of septicaemic plague is to be regarded as dangerous and capable of spreading the disease, the actual spread of the infection being occasioned indirectly.

The question of prophylaxis becomes a serious one when we have to deal with the second type of plague, namely, primary plague pneumonia. Fortunately this variety of plague has not often appeared in Hongkong. Each case of primary pneumonic plague must be regarded as a new focus of the disease. This form of plague spreads with great rapidity, producing family epidemics, to be followed by epidemics of congregations of people, and lastly often appearing as a dreadful national plague and disaster such as was found during the middle ages.

Only one other disease, namely, Influenza, can be compared with primary plague pneumonia in regard to infectivity and tendency to pandemic extension. In all cases of primary pneumonic plague, the drop infection of Flügge plays the predominant part in the conveyance of the infection.

So different are the two types of epidemics found in plague, that for ages they were regarded as distinct diseases. The septicaemic type with the presence of bubonic swelling was formerly known as "oriental plague," the pneumonic type of the disease being called "Pali," or "Lung pest."

Recent research has shown that individuals who have apparently completely recovered from pneumonic plague may harbour plague bacilli in the sputum for a considerable period of time.

The lessons taught us by the various epidemics of plague during recent years show very clearly the modes of development of these different types of the disease. It has been shown that in endemic plague foci as well as in recently infected areas, the disease appears first in the rat. Rat plague is the primary type of the disease. And further this outbreak amongst the rats is usually the result of conveyance of infection through plague ship rats.

Again in endemic areas the more benign type of the disease is usually found.

Primary pneumonic plague can usually be traced, through the benign type of the disease, to a primary affection of rats.

These preliminary data are necessary in order to formulate the principles underlying the special prophylactic efforts against the disease in its various forms.

The methods at our disposal for the prevention of the spread of the disease to other parts, have already been dealt with under "General Prophylaxis." Supposing, however, a case of plague occurs in a previously healthy area, prophyaxis has a double duty to perform. In the first place, it must carefully guard against a possible outbreak of primary pneumonic plague, and secondly it must cope with the already existent rat plague.

Outbreaks of lung pest, either isolated or epidemic, can be dealt with simply. Here man alone is the carrier of the infection. The rat has nothing to do with it. Therefore the enforcement of the strictest isolation and the thorough disinfection of all discharges fulfil all that is required.

Not only have cases of pneumonic plague to be isolated, but also all instances of the septicaemic disease. The discharges from these cases have to be regarded as equally dangerous.

As a general rule, all cases of plague, no matter what variety of the disease is present, ought to be isolated.

Special precautions have to be enforced when dealing with the primary pneumonic type of the disease. Here rigid isolation is necessary, even from cases of the other types of plague. Something of the nature of a mosquito net ought to be used, not to prevent the access of mosquitoes, but mainly to guard against the aerial distribution of the minute particles of sputum which are so dangerous. Doctors

and attendants on such cases have to exercise the greatest precautionary measures possible. Convalescent cases must be kept isolated until all plague bacilli have disappeared from the sputum.

It has already been mentioned that as a general rule all cases of plague ought to be isolated. No exception to this rule can for a moment be entertained in regard to primary pneumonic plague. In dealing, however, with the disease as met with here in Hongkong, namely, the septicaemic form with its bubonic manifestations, the question of isolation need not be so rigidly enforced. The possibility of the spread of infection from these cases is limited to the excretions and secretions from the patients, and in any well regulated Hospital, where the thorough disinfection of such discharges can be carried out, the treatment of such septicaemic cases of plague can be as sucessfully accomplished as the treatment of severe cases of enteric fever.

Further, of great importance is the supervision of the relatives and friends of all cases of plague. *The isolation of contacts is of the highest importance.*

No plague stricken city can be said to have its sanitary arrangements complete, unless ample provision has been made for the provision of segregation camps.

Probably the most important part of the campaign against plague is that directed against rat plague. Were man the only means of harbouring plague, there is little doubt of our soon gaining complete mastery over spread of the disease. The results obtained by thorough disinfection of houses, have clearly shown this to be true. Yet, notwithstanding the non-occurrence of further cases of plague in these houses disinfected, fresh cases in the immediate neighbourhood occurred. This fact, coupled with our knowledge of the part played by infected rats, has led to a modification in our cleansing and disinfecting system. Now-a-days, if plague is to be stamped out, thorough disinfection, cleansing, and destruction of rats of whole districts must be undertaken. The methods as applied to single houses or units would appear to be of no value. The generalised disinfection and cleansing, strongly recommended by Sir Horace Pinching, has given excellent results in the hands of Gotschlich, Bitter and others.

So far as *rat plague* is concerned, it would appear that this form *is mainly responsible for the bridging over of the various epidemics of the disease in man.*

The clinging of plague to one particular spot, and its periodical re-appearance, mostly at definite times of the year and at the season of the year when rats are most prolific, points to the fact that the disease is maintained in the body of the rat. My own researches show the presence of rat plague thoughout the whole year. Plague in man in Hongkong is only present in epidemic form during certain seasons of the year.

I am convinced that the rat harbours the disease in a chronic or latent form, which continues until the season when rats are very prolific. At this period, the disease again becomes virulent through the bodies of young rats. The rat epidemic and mortality assume greater proportions and sooner or later the disease breaks out in man.

That plague may be chronic and latent in rats, the virus being maintained for several seasons, has been experimentally shown by the laboratory experiments of Kolle and Martini (Dent. Med. Woch. Nos. 1-4, 1902). They are strongly supported by Gotschlich, and it is our intention to verify these results if possible in Hongkong.

In previously non-infected districts, rat plague usually appears in advance of human plague. In endemic areas, where rat plague is constantly present, the increase in the rat epidemic appears in advance of plague in man.

It must not be forgotten that rat plague may exist for an indefinite period without the disease appearing in man. This fact is of importance to sea port towns. In such towns human plague may not have made its appearance, yet plague may exist amongst the rats. *The occasional systematic examination of the rats of such cities or towns would appear to be of value.* The recognition of the disease in rats, previous to its appearance in man, would simplify the prophylaxis to an extreme degree.

Unfortunately the methods at our disposal for the destruction of rats are few, especially when applied to a generalised destruction of the species.

The various poisonous preparations in the market are of little value.

The Bacillus Danysz has not so far justified the hopes at first entertained for it. Some observers as BRONSTEIN (Deut. Med. Woch. No. 34, 1901) and KISTER (Deut. Med. Woch. No. 18, 1901) have obtained good results on a small scale. On the other hand, such bacteriologists as KOLLE (Deut. Med. Woch. No. 4, 1902), ABEL (Deut. Med. Woch. No. 99, 1901), KRANSZ (Deut. Med. Woch. No. 22, 1901) and others, have had uniformly bad results. My own results are in conformity with those of the latter workers. Recently Professor ROUX of the Pasteur Institute in Paris has had wonderful results with his virus. I have put myself in communication with him in regard to his methods, which I hope to apply in Hongkong which is veritably rat infested.

Summary of Prophylaxis.

The foregoing principles of general and special prophylaxis have been stated in as concise terms as possible. The prophylactic measures against the introduction of the exotic into a sea port or inland town have been dealt with. It only remains now to sketch as briefly as possible the measures which I consider necessary to deal with the disease after its introduction. These consist in the following:—

(1.) The absolute control of provinces supposed to be infected.

(2.) An early recognition of the disease, which is attained through:—

- (*a.*) Compulsory post-mortem examinations.
- (*b.*) Immediate notification of all cases to the sanitary authorities.
- (*c.*) Systematic search in infected areas and neighbourhood for other cases of the disease and sources of infection.
- (*d.*) The examination of rats.
- (*e.*) The provision of opportunities for the study of the disease from all points of view.

(3.) The isolation of infected persons if necessary.

(4.) The medical supervision of relations and contacts.

(5.) The provision of segregation camps.

(6.) Wholesale measures must be directed against rats and other vermin.

(7.) The education of the people especially in regard to cleanliness, cooking of food, boiling of water, etc.

(8.) Skilled veterinarian supervision of all food supplies.

(9.) The thorough disinfection of infected districts.

(10.) The thorough cleansing of non-infected districts.

In the above list *protective inoculation is not recommended.* Such protective powers as are conferred on man by the inoculation of plague vaccine are transient. It is doubtful if the protection afforded lasts more than a few weeks.

Nor is the employment of plague serum advocated. Such sera contain only part of the complex molecular body requisite for complete bacteriolysis, hence the results obtained. Much more research is required in this direction before we find a specific serum for plague.

Again, *the wholesale employment of disinfectants is not recommended.* They are expensive and their beneficial action in general is doubtful. The employment of disinfectants ought to be restricted to actual infected areas. The promiscuous use of disinfectants as cleansing agents in districts not infected is to be discouraged. Much more, or at least as much good, accrues from *the use of soap and a plentiful supply of water.*

During the absence of epidemics of plague in man, our energies ought to be directed against the omnipresent rat plague. In the absence of primary pneumonic plague I am convinced that the eradication of plague from any country, district, city or town is subject to the complete extermination of rat plague.

WILLIAM HUNTER.

Epizootic Plague.

The disease amongst animals occupies quite a special department of its own. Until a few years ago, the occurrence of the disease amongst animals, appears to have attracted but little attention. Indeed, so severe were the past outbreaks of the epidemic that little or no time was available to regard the presence of the disease in animals other than man.

With the advent of more perfect knowledge in regard to the ways of infection, our attention has been directed to the occurrence of diseases in animals, diseases which, when compared with those occurring in man, appear to be similar. The question has therefore arisen—a new one indeed—as to the part played by animals in the dissemination of certain diseases amongst the human race. It would be quite impossible, indeed unnecessary, to sketch, even briefly, the connections between disease in animals and in man. Summing up the available evidence, we find much in favour of such a connection. Indeed there is good reason to suppose, that in the production of certain widespread and epidemic diseases, animals play an important role, if not the initial factor, in the spread of the disease amongst the genus homo.

It must be difficult for a certain class of professional men to get away from the time worn causes of epidemic disease. Indeed, in all text books on plague, one finds the old dogmas of infection, most carefully reproduced, namely, the solution of the problem by a recognition of:—

(*a*) The communication of the infection from the sick direct.

(*b*.) Indirect means.

(*c*.) Place infection, etc.

As Ashburton Thompson says, such a table of causes would amply explain the epidemicity of plague.

The adherents of such a classification of etiology appear to take no cognisance of the advances made by bacteriological research. It would appear from the most recent works on such a subject, that the ways and means afforded to the B. pestis to produce infection, the course of plague infection, and the exact problems underlying the spread of the pest, must undergo remodelling upon the lines indicated by the results of modern epidemiology.

As has already been mentioned, the recognition of epizootic plague, as an important factor in nature, is of recent date. At the present day, the epizootic has become one of the most engrossing researches in regard to plague. Sanitary authorities are already recognising that in epizootic plague, they have to deal with probably the greatest disturbing factor in their efforts to stamp out the epidemic. It would be a difficult matter to specialise in regard to the particular species of animal which attracted the attention of past hygienists, as a factor in plague dissemination.

At the present day, however, one cannot take up a book dealing with plague without being struck with the prominent part devoted to rats as disseminators of infection. In fact on the perusal of many such manuscripts one is drawn to the conclusion that rats, and nothing but rats, are responsible for the existence of epidemic plague around us. Going into the question more thoroughly, however, it is difficult to guage exactly the premises upon which a conclusion has been drawn. We have to consider whether rats are the only disseminators of plague—in fact do they disseminate plague epidemics at all—or granting that they are responsible for the occurrence of such—are they solely responsible, or simply partners in the wholesale sewing up of the infection to the human species.

From all works on plague, I have drawn the conclusion that rats—and these vermin alone—are the plague spreaders. This would appear to be too dogmatic a conclusion. Mice associate with rats, are susceptible to plague, domesticate with man where possible, so that it seems probable that under certain circumtances these animals might play as important a role as their neigbours the rats.

Again, the disease is known amongst cats, fowls, pigs, and oxen—all of which animals are more a less occasionally in close contact with man. It therefore seems probable that the existence of an epizootic in plague as a factor or epidemic dissemination, must not be dogmatically restricted to rats but extended to those other animals which occasionally have intimate relationships with the human species.

At the same time the question of the epizootic is a recent one, and in view of its having been applied more particularly to rats, one must enquire as to reasons and the facts upon which such a theory has been founded. It is said that plague is primarily a disease of the rat, that it is commonly communicated to man from the rat, and that man and the rat may be reciprocally infective.

Again epidemics may be present without epizootics and *vice versa*.

Much has been written in regard to the close inter-relationship existing between the epizootic and the epidemic. The evidence at present available would appear to fall short of absolute proof of a direct connection between the two. An occasional and frequent concurrence between the two has been found, but the question whether the epizootic is the cause or an incident of the epidemic is still left unanswered. The experience of THOMSON in Sydney during 1900 was that plague rats were the sole source from which the infection was communicated to man. The evidence in support of such was however incomplete.

The literature in regard to the relation of rat plague to human plague is defective. SNOW's observations note the incidence of plague in rats, but do not suggest any connection between the epizootic and the epidemic. The Indian Plague Commission do not lay any weight on plague infected rats as agents in the dissemination of plague epidemics. BRUCE LOW's papers on Bubonic Plague, dated July, 1902, lead me to believe that man and the rat are reciprocally infected. No evidence is forthcoming in regard to the question from *a priori* grounds.

Many plague workers have much difficulty in perceiving how plague infection could be converged from rat to man.

To explain the transference of the disease from the rat to man, HANKIN (Annal Pasteur, 1898) concluded that plague in man stood in relation to the accessibility to rats and that probably some intermediary insect was necessary to communicate the infection from rat to man. SIMOND upheld these observations, and these two investigators may be said to be the only exponents at present of the epidemiological factor of the part played by rats in the dissemination of the disease. That suctorial insects have much to do with the cause of bubonic plague is by no means obvious. The reports of recent years in regard to epidemic and epizootic plague, do not convince one in regard to the inter-relationship of the two outbreaks.

The cause of this is mainly, in my opinion, the failure to systematically examine both outbreaks. Before anything like a causal connection can be established between two such outbreaks, it would appear necessary to closely examine the severity of the epizootic and then to compare this with the epidemic, particularly in regard to its course, time relations, exact actions, and continuance.

Such has been carried out systematically in Hongkong since the commencement of 1902. Over 300,000 rats have been examined for plague infection. Many of these were caught alive, the existence of acute rat plague, chronic rat plague and latent plague infection has been determined. Curves have been prepared for each of these years, namely, 1902, 1903 and part of 1904, and the relations of the epizootic have been noted during the interval between epidemics.

In such a way, it has been possible to map out clearly the courses of both outbreaks. For details in regard to these one is referred to the Histories of the courses of the epizootics. In dealing with epizootic plague, my attention has been directed more or less directly to rat plague, but the varieties of the disease in animals belonging to other species have not been lost sight of. In fact it has been my object to obtain for examination almost every animal possible, which was sick or died since I arrived in the Colony. By thus stimulating the laymen to the importance of having his dometic pets or other animals examined bacteriologically, I have been able to find plague existent in animals, to a degree, rather suprising to the minds of the ordinary sanitarian.

The following report on epizootic plague is merely the story of my experiences in regard to the disease amongst a number of animals, coupled with brief notice of the existent knowledge in regard to the incidence of the disease in such animals and found affected.

WILLIAM HUNTER.

Plague in Rats.

In all treatises dealing with plague, which have been published during the past year or so, one finds a considerable amount of attention devoted to the question of the occurrence of plague infection in rats, and the dangers attached to the presence of such infected vermin in the direct vicinity of man.

Sanitary bodies, although thoroughly convinced as to the presence of such epizootics in certain plague endemic areas, are by no means convinced as to the exact role played by such plague infected animals in epidemiology. In short, much evidence is wanting to prove conclusively, that some relation exists between rat plague and an epidemic of plague.

We may find both present. The epizootic and the epidemic may run concurrently; yet one finds it difficult to become reconciled to the conclusion that plague is primarily a disease among rats, and that such infected vermin are responsible for the outbreak of the disease amongst the human species.

The present research is an attempt to grasp as thoroughly as possible the whole question of the epizootic. The reader of this report is left to gather his own conclusions from the matter now presented.

Plague in rats is by no means a recent discovery. High rat mortalities were noted by the ancients during epidemics of plague. Classical, mediæval and modern literature furnishes us with many interesting details in regard to the susceptibility of various animals, especially house vermin, to plague infection. The general lay opinion in regard to the matter is that, during plague epidemics, an increased mortality is observed amongst the animals in the infected district, and that such a death rate is noticeable especially amongst rats.

It would be difficult to determine who propounded the rat theory of plague epidemics. The prominence to the epizootic, during recent years, has arisen out of better acquaintance with the bacteriological and epidemiological aspects of the disease.

Avicenna in the year 1000, noted the presence of a high rat mortality during plague epidemics. He says:—"*Et de eis quae significant illud est ut videas Mures et animalia quae habitant, sub terra fugere ad superficiem terrae et parti sedar e.g., commoveri hinc inde sicut animalia ebria.*"

Again Nicephorus Gregoras in 1348 and Orbaetus in 1771 in their treatises on Medicine, look suspiciously upon rats as having some relation to outbreaks of epidemic plague. Reports such as these are extremely interesting to investigators of the present day, who are endeavouring as far as possible to bring this rodent into close relationship with the occurrence of plague amongst human beings.

Plague research is, at present, directed to the rat, the occurrence of the disease in his body, and the channels through which the plague bacillus is transported from his body to that of man.

Simpson, in his Report on Plague in China and Hongkong, has given us an excellent resumé of the beliefs held by the Chinese in regard to the prevalence of the disease in animals such as rats. It is evident that the opinion is widely diffused amongst the Chinese that there exists some relation between the epizootic and the epidemic.

In their writings the Chinese make frequent mention that during, or immediately preceding, plague epidemics, severe epidemics occur amongst their cattle—frequently called Rinderpest—their fowls, and their house vermin.

In dealing with the subject of Rat Plague, I have endeavoured to more or less systematise the subject. The latter is a large one, and unless some method be employed in order to grasp the subject as widely as possible, points of great importance are bound to be overlooked.

Rat Plague.

1. General Remarks.
2. Symptoms of Acute Rat Plague.
3. Post-appearances of Acute Rat Plague.
4. Symptoms of Chronic Rat Plague.

5. Post-mortem appearances of Chronic Rat Plague.
6. Latent Plague in Rats.
7. General Modes of Infection of Rats:—
    (*a.*) From other rats.
    (*b.*) From man.
    (*c.*) From food.
    (*d.*) From other infected material.
    (*e.*) From vermin.
8. Infection of Healthy Rats on Board Ship.
    (1.) In ocean going cargo boats.
    (2.) In ocean going passenger boats.
    (3.) In coasting cargo boats.
    (4.) In coasting passenger boats.
        (*a.*) By human plague.
        (*b.*) By rat plague.
        (*c.*) By other infected vermin.
        (*d.*) By infected cargo.
        (*e.*) By infected goods.
        (*f.*) By infected animals.
9. Question of Latent Infection of Ship.
10. Infection of Healthy Rats in a Sea-port.
    (1.) By incoming infected ships.
        (*a.*) Human plague on board.
        (*b.*) Rat plague on board.
        (*c.*) Latent ship infection.
        (*d.*) Infected merchandise.
        (*e.*) Infected animals.
    (2.) By conveyance of infection from an Inland Town.
        (*a.*) Rats—sewer—field.
        (*b.*) Man.
        (*c.*) Food.
        (*d.*) Merchandise.
        (*e.*) Clothing.
        (*f*) Railways.
        (*g.*) Caravans.
        (*h.*) Pilgrimages.
        (*i.*) Other animals.
11. Infection of an Inland Town.—Modes given under No. 10.
12. Natural Modes of Rat Infection.
    (1.) Question of skin infection.
    (2.) Alimentary Incorporation.
    (3.) Inhalation Infection.
13. Natural Modes of Elimination of Infection.
    (1.) Mucus and saliva of the mouth.
    (2.) Urine.
    (3.) Fœces.
14. Question of Danger of Contact with dead Infected Rats.
15. The Course of Plague Epidemics in Rats.
16. The Relations existing between the Epizootic and the Epidemic.
17. The existence of acute rat plague epidemics.
18. The existence of chronic rat plague epidemics.
19. The part played by rats in bridging over plague epidemics in man.
    (*a.*) The influence of acute rat plague.
    (*b.*) The influence of chronic rat plague.
    (*c.*) The influence of latent rat plague.

20. Coincidences between the epizootic and epidemic.
21. The precedence of the epizootic.
22. The necessary Intermediary between the epizootic and the epidemic.
23. The occasional systematic examination of rats in sea-port cities.
24. The Influence of fumigation and disinfection on plague infected rats.
25. The question of Railways and Rats.
26. The question of general epizootic plague from rat plague.

So far as we know the rat is the most susceptible animal to plague infection. All species of rats appear equally susceptible. Hence the widespread occurrence of spontaneous infection amongst this species of rodents. The disease may occur in various types in these animals.

Acute plague infection would appear to be the most frequent type of the disease met with. Chronic infection is also prevalent and its presence is of importance epidemiologically.

There is good reason to believe in the prevalence of *latent infection in rats*. This would appear to have much to do with the continued prevalence of infection amongst rats, and with *chronic rat plague*, to have considerable importance in regard to *the bridging over of plague epidemics*.

Acute Rat Plague, Symptomatology.—The rat may become infected with plague through many channels. According to the method of incorporation of the plague virus, the animal suffers. Sooner or later the inoculated animal becomes dull and refuses to move actively about its cage. It crouches and if left alone usually takes up a slouching position in one of the corners of its cage. The animal sits in a curled up posture, emitting from time to time short sharp squeals. There is complete loss of appetite, ruffling of the hair, mucous discharge from the mouth, diarrhœa, and a distinct rise in temperature. Handling of the animal would appear to produce pain. The abdomen is extremely tender to touch. Occasional twitching of the muscles of the extremities are observed. The reflexes are decidedly exaggerated. For a day or two previous to death, the animal appears unable to move, irregular convulsive seizures take place, and the urine and fæces are voided with each acute tonic spasm. Before death, the animal would appear to be in great pain. It falls on one side, breathes convulsively, is absolutely helpless, becomes gradually comatose, and dies as the result of a convulsive seizure. Death usually occurs in from three to five days.

Post-mortem Appearances of Acute Rat Plague.—The subcutaneous tissues are congested and show scattered and varying sized hæmorrhagic extravasations. The superficial lymphatic glands are enlarged, slightly œdematous, congested on section with occasional corticel hæmorrhage.

In certain instances, distinct superficial bubonic formation may be found.

If the animal has been inoculated through the skin, one finds around the point of inoculation, considerable swelling, œdema, and infiltration of the connective tissue with blood.

The general appearance presented by the internal organs, is that of vascular injection. The blood itself is dark in colour and fluid. The myocardium is in a condition of granular degeneration. The lungs are full of dark coloured, thick, blood, and frequently one finds apoplectic looking patches of consolidated tissue on section of the visci. The liver, spleen, and kidneys, in addition to congestion, frequently contain small areas of necrosis. These resemble necrotic patches found in the liver in cases of typhoid fever.

The peritoneal cavity usually contains an excess of blood stained fluid. The peritoneum is smooth and shiny. No inflammation is found. Small retro peritoneal hæmorrhages are often found. The mesenteric lymphatic glands are usually enlarged and congested. Occasionally extensive hæmorrhages have been found between the layers of the mesentery, embedding enlarged, and hæmorrhagic looking lymphatic glands. The walls of the internal gut are thickened, soft and œdematous. Erosions and petechial hæmorrhages are found in the mucous membrane. The contents of the intestine are often deeply stained with altered blood pigment.

The central nervous system is congested, with occasional blood extravasations. Examined bacteriologically, almost all the organs and tissues are full of plague bacilli. The spleen is often found choked with bacilli. Large numbers are found in the urine, fæces, and saliva.

In artificially inoculated animals, the tissues about the point of entry of the virus are infiltrated with B. pestis.

If the inoculation of the rat be carried out cutaneously, according to the methods advocated by the Austrian Plague Commission, the subcutaneous tissues underlying the area of inoculation, are found to be infiltrated with extravasated blood and œdematous fluid in which plague bacilli are abundant. This method of inoculation does not give so certain results in the rat as in the Guinea pig.

It is an excellent method of demonstrating the presence of plague bacilli in fluid, such as the urine, fæces, etc. My experience with the cutaneous method of rat inoculation is in agreement with that of KOLLE (Zeit. f. Hyg. Bd. 36, 1901).

Chronic Rat Plague.—This form of rat plague would appear to be more common than is generally supposed. Numerous instances of this disease have been found at the Public Mortuary during the systematic examination of live and dead rats.

In general, *chronic rat plague is more commonly found during the interval between epidemics of plague.*

The question as to the relative frequency of the varieties of the rat epizootic throughout the year will be discussed later on.

At present, however, it may be said, that there exists a considerable amount of evidence in favour of the view that the epizootic is maintained from year to year through a persistence of rat plague in chronic or latent form.

Many of the live rats sent to the Public Mortuary for bacteriological examination show symptoms of some chronic wasting disorder. They show little activity. They are usually emaciated. Their hair is ruffled, matted together, and frequently areas of bare skin are found. The animals eat little. There is frequently a discharge of mucus from the mouth, and diarrhœa of a variable degree.

By keeping such rats alive and under observation, facts of an interesting nature may be obtained.

An examination of their blood frequently shows the presence of plague bacilli.

Such animals live for an indefinite period of time. The observations of others, *e. g.*, ROLLE and MARTINI (Dent. Med. Wochen, 1902) prove that chronic plague may exist in rats for months.

My own observations are incomplete. Owing to the want of proper accommodation and assistance, I was unable to carry on the experiments for a period longer than a month.

It would be interesting to follow out more closely the course of chronic rat plague. I have already made arrangements to carry on further experiments in regard to the subject.

Rats suffering from chronic plague look pitiable objects of suffering. They become more and more emaciated. Chronic diarrhœa is present and occasionally skin eruptions such as papules make their appearance.

Death takes place from exhaustion or some intercurrent disorder.

During life, these animals discharge plague bacilli with their fæces and urine.

Post-mortem Appearances of Chronic Rat Plague.—There is great emaciation and loss of adipose tissue. The animals may simply be skeletons within their skins.

Congestion of the tissues is not a marked feature. The lymphatic glands are frequently found enlarged and hard. On section, areas of necrosed tissue are found. These consist of thick cheesy looking material. Plague bacilli are rarely found in such areas of dead tissue. The internal organs show small areas of necrosis—recent or old.

The lungs are fibrous, or indurated and may contain capsulated areas of dead tissue.

Similar pathological appearances are found in the liver, spleen, and kidneys.

Plague bacilli are found in the various organs and tissues. They are, however, few in number. Such dead tissues when emulsified and administered to other healthy rats are able to reproduce the disease, even in acute form.

The spleen contains the largest number of plague bacilli. This organ is much enlarged. In one or two occasions, several prominent greyish white areas of necrosis have been found, resembling closely the condition met with in tuberculosis.

Latent Plague in Rats.—Theoretically there is no reason why this should not occur.

So far no extended series of observations has been made in this direction.

KOLLE, from certain laboratory experiments, is a strong believer in the existence of latent plague amongst rats. He is supported in his conclusions by GOTSCHLICH.

My own observations are strongly suggestive of latency in rat plague.

On a favourable opportunity presenting itself, I propose to carry out a series of experiments with a view of determining as exactly as possible, the course and duration of chronic rat plague, its relation to acute rat plague, the question of latent rat plague, seasonal variations, prolific influence on rat plague, and the factors upon which the appearance of the different types of the disease depend.

Further details in regard to latent rat plague will be found in a subsequent part of this research.

General Modes of Infection in Rats.—Rats may become plague infected either naturally or artificially.

In order to define as clearly as possible the avenues of spontaneous infection it will be more convenient to discuss the artificial methods of induction of the disease in these animals, and then draw conclusions as to the probable natural means of conveyance of the infection to the rat.

(1.) The Artificially Induced Disease.

(*a.*) By subcutaneous inoculation.
(*b.*) By cutaneous inoculation.
(*c.*) By intra-peritoneal inoculation.
(*d.*) By inhalation.
(*e.*) By contact with uninjured mucous membranes.
(*f.*) By feeding.

(*a.*) *By Subcutaneous Inoculation.*—Experimentally this is one of the most effectual methods of producing plague infection in the rat. The type of disease induced, is usually acute rat plague.

At the same time, it would appear that all rats do not react equally to subcutaneous inoculation. The same degree of susceptibility is not shown by different rats to a definite culture or strain of the B. pestis.

In some cases, a mere prick with the point of an infected needle is sufficient to occasion the infection. (German Plague Commission.) In other cases, however, a very sensible quantity of a culture of the B. pestis must be introduced in order to call forth the disease. (Indian Plague Commission.) It is said that occasionally rats are found which give no reaction to inoculation of considerable quantities of fully virulent cultures. (Austrian Plague Commission.) In my opinion, the latter must be indeed rare, in regard to the variability of rats in their degree of susceptibility to plague infection. Professor SIMPSON and I had an experience similar to that of the Indian Plague Commissioners. We found that occasionally it was a difficult matter to produce plague in certain rats. Some were easily infected. Others only succumbed to the infection after most severe tests had been applied.

It is possible to produce plague in all species of rats by subcutaneous inoculation.

(b.) By Cutaneous Inoculation—i.e., by rubbing the plague virus into the skin. This method of reproducing the disease in the rat or other small animals was strongly advocated by the members of the Austrian Plague Commission. The abdomen of the animal to be inoculated, is shaved, and the plague infected material is rubbed into the bare skin.

This method is one of great value for purposes of diagnosis. It is very useful if applied in the case of mixtures supposed to contain plague bacilli such as the fæces, food, clothing, etc. For such purposes, I have found it of great use in determining my results already detailed under the heading of Human Plague. The isolation of plague bacilli from such material as fæces, etc., is a matter of the greatest difficulty. In fact, in many cases, our ordinary cultural methods would fail to give us a positive result. On resorting to the experimental method direct, namely, the cutaneous incorporation of the supposed virus, the results are found to give great satisfaction.

The cutaneous method of inoculation of the rat would not appear to give so constant results as in the case of the Guinea pig. The method of cutaneous inoculation of plague, has been interpreted as a good instance of the passage of the B. pestis—or even of any micro-organism—through the unbroken skin. On careful consideration of all the circumstances present, however, such a conclusion is by no means warranted. During the process of shaving, no matter how carefully the procedure is carried out, small breaches of the continuity of the skin are bound to be made. They may occasion no hæmorrhage, and even be microscopic, yet these wounds are of sufficient magnitude to permit the passage of an organism like the B. pestis. The reason why rats are not so susceptible to this mode of infection is by no means clear, nor are the negative experimental results of KOLLE explainable. The skin of the Guinea pig is more delicate, and easily wounded than that of the rat, and again the question of expert shaving is a factor not to be forgotten in performing such an experiment.

(c.) By Intra-Peritoneal Inoculation.—Little of interest from the point of view of dissemination of plague, is attached to this method of plague infection.

It has been noted that for success with this method of incorporation, small doses of the virus must be employed.

Again the plague bacilli found in the peritoneal exudate show marked capsular formation.

According to KOSSEL and OVERBECK (Arb. Kais. Ges—Amt. Bd. 18. 1901) little change is found in the peritoneum after such an inoculation of plague bacilli.

(d.) By Inhalation.—Rats are very susceptible to this mode of infection when artificially induced. The most satisfactory experiments in regard to this question are those conducted by MARTINI (Zeit. f. Hyg. Bd. 38. 1901). This investigator found that rats by inhalation of virulent plague bacilli, contract a primary plague pneumonia.

The passage of the organism by inhalation from one rat to another, would appear to be the most satisfactory method of raising the virulence of the B. pestis. This would also appear to be the case in regard to the history of pneumonic plague in man, and would account for the rapid spread of this deadly form of the disease. Of great interest in regard to the pathology of the disease, is the statement made by MARTINI, that plague bacilli isolated from such pneumonic case, gradually acquire the power of producing fatal lung plague when incorporated subcutaneously or intra-peritoneally.

(e.) By Contact with Uninjured Mucous Membranes, e.g., the nose, conjunctiva, etc.—The members of the German Plague Commission were the first to show that by smearing plague infected material on the mucous membranes of the conjunctiva and the nose of the rat, general plague infection could be induced. They mention the occurrence of bubonic swellings in the neck and great enlargement of the spleen as results of such a method of inoculation.

They concluded that the infection was occasioned through the intact mucous membranes. Batzaroff (Annl. Past. Bd. 13, 1899) and Bandi (Revue d'Hyg. Bd. 21) came to a similar conclusion, but found in addition that this method of inoculation was frequently followed by a primary plague pneumonia. It is obvious that here the infection was not through the intact mucous membrane but by way of the respiratory tract to the lungs.

Again, infection of the conjunctiva is frequently followed by general plague septicæmia, and post-mortem marked pathological changes are found in the gastro-intestinal tract. The stomach shows small and large hæmorrhages. A similar condition is found in the intestine. The changes found are identical with those met with after feeding with plague bacilli or plague infected tissues.

The question would appear to arise as to whether the infection really takes place through the uninjured mucous membrane or is conveyed from the conjunctiva and the nose to the lungs or alimentary tract. In this connection the results obtained by Römer, Mayer, and Hirota (cit. by Kolle) are of great importance. These observers admit the occurrence of plague infection, after smearing the conjunctiva with plague infected material. They found, however, that if the nasal duct be previously ligatured, such an infection does not occur.

Such a result appears to offer an explanation of the exact mode of plague infection in such cases.

The post-mortem changes found after such a method of infection, are largely centered in the alimentary tract. The stomach is deeply congested. The intestinal canal is swollen, œdematous and, in some cases, ulcerated. The mesenteric lymphatic glands are also swollen and œdematous, and contain large numbers of plague bacilli.

From the experimental evidence at one's disposal, the effect of smearing the mucous membranes of the conjunctiva and the nose with plague material is to produce plague infection per os. The causal agents reach the mouth or throat, and either set up the pneumonic manifestation of the disease, or pass by the œsophagus to the gastro-intestinal tract, eventually giving rise to a typical septicæmic plague.

(*f.*) *By Feeding.*—This method of infection would appear to be the commonest for the rat. The type of the disease is septicæmic. The condition of the gastro-intestinal tract is similar to that found after smearing the uninjured mucous membranes of the nose and conjunctiva. The question of feeding and the origin of plague in the alimentary tract have been so frequently mentioned in this research, that one has little or no further comments to make in regard to the subject.

General Conclusions regarding Artificially Induced Rat Plague.

(1.) Plague in rats is either acute, chronic, or latent.

(2.) Septicæmic plague is the most characteristic type of the disease.

(3.) Bubonic swellings are not marked features of rat plague.

(4.) Gastro-intestinal inoculation gives constant results.

(2.) *Spontaneous Infection or the Naturally Induced Disease.*—Natural infection through the skin would not appear to be common. The effects of one infected rat biting a healthy rat, scratching, and wounds produced by fighting, etc., are not of great importance in regard to the spread of the rat epizootic.

The part played by fleas would appear to be over-estimated. (*Vide* "Insects and the Spread of Plague.")

The infection per os would appear to be the most frequent mode of dissemination of plague amongst rats.

The opinions expressed by different observers, in regard to infection per os, are of a conflicting nature. Gibson, Hankin and Simond in India obtained inconstant results with feeding experiments. Their observations are more or less isolated.

The majority of recent experiments goes to show that plague infection per os is the all important mode of contraction of the disease in the rat.

My own results are in perfect accord with those obtained by Russian, Austrian, and German Plague Commissioners, who concluded that plague could be conveyed to rats by feeding them on plague infected material, and that in a state of nature, rats generally become infected in this manner.

General Sources of Infection.

(1.) *Direct from man.*—Urine, fæces, sputum, etc.
(2.) *Direct from rats.*—Contact, food, urine, fæces, saliva.
(3.) *Food.*
(4.) *Contact with Infected Matter.*—In infected houses, in infected ships, clothing, cargo merchandise, etc.
5. *Other vermin.*—Mice, cockroaches, ants, flies.

Many of the headings included in the general table on rat plague, are sufficiently clear in themselves.

Unfortunately, I find it impossible to deal with these thoroughly at the present time.

WILLIAM HUNTER.

The Relation of the Epidemic to the Epizootic.

The dictum of Koch and many epidemiologists that plague is primarily a disease of the rat, secondarily a disease of man, and that epidemic plague is entirely dependent on the presence of widespread plague infection in rats, has become widely recognised and accepted by many plague experts. If we look into the evidence in favour of such a conclusion, little information of a definite nature can be obtained.

Up to the present time, no research has been accomplished which would justify the conclusion that plague rats are the only sources from which the virus is communicated to man. We must admit that there is a good deal of evidence in favour of such a method, but, notwithstanding the constant influx of additional supplementary proof, there yet remains to be proved, the direct connection between epizootic rat plague and epidemic plague.

Rats and man suffer from plague. They are susceptible to an identical affection. This is practically the sum total of what has so far been accomplished in regard to the part played by the rat in the causation of human plague. Ashburton Thompson, in his Report on Plague in Sydney for 1902, gives an excellent resumé of the present status of our knowledge in regard to the rat question.

He has come to the conclusion that *our promise of safety for the future lies in habitually excluding rats from inhabited premises.* Although admitting the justification of the rat theory of plague, he sees, like I did myself, many obstacles in the path, before a clear understanding of the factors underlying the whole question is attained.

Notwithstanding the dogmatisms of some plague experts in regard to the part played by the rat in the production of plague epidemics, much still remains doubtful. The conjectures that rat plague is frequently communicated to man or, as Ashburton Thompson says, that man and the rat in the usual circumstances of propinquity are recriprocally infective, require considerable systematic research in order to establish definite proof.

In Sydney, every effort was made to settle the question. Much supplementary evidence was obtained. The conclusion was drawn that infected rats play an important, if not the most important, role in the dissemination of the disease.

Again, statements are forthcoming that epidemic plague may exist in the absence of an epizootic, that human plague may exist for some time previous to the appearance of the disease amongst rats, and that epizootic rat plague does not in every case precede or lead up to an epidemic among men.

It was from the foregoing points of view that I took up the subject over two years ago. I felt compelled to investigate the question thoroughly, and determine how far one was justified in becoming a disciple of those content with the simple theory expressed in the word "Rat."

The accompanying remarks, with charts, tables, etc., are the outcome of nearly 2½ years' systematic research into the question from every point of view which appeared to me to be of importance. In Hongkong, far removed from the centres of medical science, I have experienced considerable difficulty in keeping abreast with the status of our knowledge of this subject. A more or less constant communication has been kept up by me with the more important scientific schools of Europe, the directors of which have greatly assisted me in the task of obtaining accurate information in regard to the problems of the task which was before me.

There does not appear any necessity to discuss the question at length. Remarks, charts, tables, etc. are appended which are, in my opinion, sufficiently clear, and their interpretation is left to the readers' judgment.

I shall content myself here with concentrating the results, and applying them to the various questions which are constantly being plied by those who still appear sceptical as to the significance of the words "infected plague rats."

Observations in regard to the beliefs of our ancestors have been made in another section of this Report. Our forefathers noted that rat epizootics constantly preceded or accompanied plague epidemics.

Within the last decade, much evidence has been brought forward in regard to the relation of the epidemic to the epizootic.

The experience gained by the outbreaks of plague in the sea-ports of Oporto, Alexandria, Sydney, Kobe, etc., goes far to establish some connection between rat and human plague.

In these ports, as well as in others, the disease clung fast to the harbour town. The neighbouring cities and villages were not or only slightly affected by the disease.

Again, in the grossly overcrowded and filthy cities of the Orient, the introduction of human plague has scarcely ever been followed by the establishment of an actual endemic plague focus. In such cities or ports, in which plague broke out epidemically, these epidemics would not appear to depend on the arrival of plague infected human beings, but upon the introduction of plague infected rats.

In different plague epidemics, grain stores, in which rats preferably lodge, have frequently become the central points of the outbreak. In Bombay, plague broke out first among the Banniahs. (German Plague Commission). In Oporto, the food stores appeared to be the centres from which the epidemic spread. (Kossel and Frosch. Klin Jahr. Bd. 7, 1900.) Of great importance are rats on board ship. Examples of infected ship rats have already been cited. (*Vide* Hamburg case of ship from Smyrna, cited by Kossel and Nocht.) Another instance of the same was found in Bristol in 1901. Again, the experience gained from the condition of certain passenger ships visiting Hongkong, adds further evidence in the chain connecting rat-plague with the epidemic. (*Vide* Simpson's Report on Plague in Hongkong.)

Plague rats may be present on board ships, without the advent of human plague. Further plague rats or the bodies of plague rats are probably of greater importance than a plague infected man.

The reports of English writers, during the past few years, admit the importance of the rat in disseminating plague infection, yet the majority of their writers show that considerable difficulty is experienced in perceiving how the infection can be conveyed from the rat to man.

Snow's observations contain no suggestions that the rat is the important cause of epidemic plague.

Hankin (Past. Annl., 1898) infers that the incidence of plague, in a neighbourhood, stood in relation to its accessibility to infected rats and not to any of the commonly relied up causes as filth, overcrowding, etc. He was inclined to the opinion that some insect acted as the intermediary host of the B. pestis.

In the same year Simond stated "that the epidemicity of plague was due to migrations of plague rats and not to human intercourse".

It is evident that considerable difference of opinion exists among plague experts in regard to the communicability of the plague virus to man and the connection between epizootic and epidemic plague.

Of importance in regard to my researches are the instances of plague infection emanating from grain and food stores. (*Vide* "Food and its relation to Plague.")

Again, the general trend of opinion is against the hitherto advanced causes of epidemic plague, namely, direct and indirect mode of communication of the the disease, and place infection. My own experience of plague epidemics leads me to conclude that, apart from cases of primary pneumonic plague, the dangers of one person infecting another are over-estimated, and that *place infection*, apart from the presence of infected rats, *is of no great significance*.

We know that rats are highly susceptible to plague, and they readily communicate the infection to other rats. Rats when suffering from plague are peculiar in their habits. They leave their holes. They are apparently deprived of any sense of fear or danger when near human beings. They progress with a drunken like gait. Conclusive movements cause them to make erratic springs into the air during ordinary progression. They die suddenly, usually from convulsions.

The natives of Bombay are so frightened by the peculiar appearance of these animals, and the finding of dead rats in their houses, that they flit at once.

According to Zupitza (Zeit. f. Hyg. Bd. 30, 1899) the natives of Kisiba in Central Africa have the same dread of rats either suffering from this condition or dead in their dwellings.

These remarks bring me up to the general consideration of my own results. Much evidence has been advanced in favour of the rat theory and that, when added to the conclusions drawn from my own charts, ought to bring these two outbreaks into close relationship to each other.

Coincidences between the epizootic and the epidemic on the same premises have been found on many occasions. Frequently, however, such is mixed. I have found it impossible to go into this part of the research, namely, the determination of the incidence of rat and human plague in each individual plague infected house in Hongkong. By compiling curves of the outbreaks for each Health District of the city, it is evident that an extremely close connection exists between the outbreaks.

Time and place relations are indicated sufficiently well in the appended charts and accompanying notes. What is of great importance in regard to the whole question is that epizootic plague always precedes epidemic plague.

The possible intermediaries necessary to convey the infection to man have already been sufficiently discussed under human and rat plague.

WILLIAM HUNTER.

The Bridging of Epidemics.

From two charts which are appended, it will be seen that epizootic plague is present throughout the whole year. In the remarks to these charts, various conclusions are drawn in regard to the connection between the outbreaks.

What we have to explain is yearly recrudescence of the epizootic and the epidemic.

So far as the epidemic is concerned, my charts appear to show that *human plague is dependent on rat plague. Within 10 or 14 days after the commencement of the epizootic, human plague appears. This is true, not only of Hongkong in general, but of each individual district in the Colony.*

Therefore in dealing with this question, we have to explain the behaviour of the epizootic. *Rat plague is present throughout the whole year.*

It becomes epizootic at certain times of the year—in *Hongkong during the first quarter of every year.*

In order to explain the regular reappearance of the epizootic, we have to consider the question of *the virulence of the B. pestis, and the period when rats are most prolific.*

The plague bacillus is an organism which is liable to sudden alterations in its virulence. Two races of the bacillus may be cultivated under the same conditions for months. One may retain its virulence. The other may lose its virulence, either partially or completely. This loss of virulence may take place suddenly.

All proofs we have at present show that climatic influences have absolutely nothing to do with the question. Plague epidemics occur in Siberia as well as in the equatorial regions. Sunshine, humidity and rain do not appear to have any determining influence on the occurrence of plague epidemics. The reports of the Acting Medical Officer of Health show this more or less clearly. *We have to remember the constant presence of rat plague, and the occasional presence of human plague. Further it must be borne in mind that no rise in human plague is found unless it be preceded by a rise in rat plague.*

Climatic influences in the production of human plague loose their significance by the establishment of the influences of rat plague. At the present day, few epidemiologists treat the climate seriously.

It is known that the plague bacillus may remain virulent for a considerable length of time at the temperature of 95-100° F.

By the continued passage of the plague bacillus through Guinea pigs (cutaneous inoculation), *practically avirulent stocks of the B. pestis are obtained* (Kolle and Martini).

This also obtains in rats, as I have found by experiment.

Such avirulent cultures produce chronic and marasmatic plague.

Kolle and Martini found that cultures of the B. pestis, which were highly virulent for Guinea pigs, would not kill rats with certainty.

I have found that rats occasionally show considerable resistance to infection when fed upon the plague infected tissues of man and other animals.

Other facts in regard to the peculiar alteration in the virulence of the plague bacillus might be mentioned, but space will not permit of one going more deeply into the subject.

My researches lead me to the following conclusions. (*Vide* charts.)

Plague is primary epizootic. Within a week or a fortnight it also becomes epidemic.

Throughout the epizootic period, the type of plague amongst the rats is acute. Subsequent to the epizootic and epidemic plague periods, acute rat plague is also met with, but *chronic rat plague becomes predominant.*

During the interval between plague epidemics, rat plague is present, but the type of the disease is chronic.

My results show that:—

Acute rat plague is followed by epidemic plague.
Chronic rat plague bridges over epidemic plague.

My results show further that the percentage number of live rats caught and found infected during the interval between two plague epidemics, is much greater than that found during plague epidemics.

The following is interesting:—

1903—% Live Rats found Infected.

January,	10
February,	13
March,	8
April,	—
May,	3
June,	1
July,	4
August,	1
September,	13
October,	30
November,	13
December,	15

About 75 per cent. of the rats caught alive and found infected, suffer from *chronic plague.*

An explanation of the occurrence of chronic rat plague, as a sequel to an epizootic of acute rat plague is by no means easy. From what has already been said, the continued passage of the B. pestis through the body of the rat tends to render the organism less virulent. *A strain of the bacillus which excites acute rat plague during the early passages, will only cause chronic rat plague during the later passages.*

In the plague bacillus we are dealing with an organism of the group of hæmorrhagic septicæmias. Such bacteria when introduced into the bodies of certain animals are known to progressively lose their virulence (Danysz). They give rise to outbreaks of spontaneous disease in animal. *On the recrudescence of the epizootic the virulence again becomes increased. During the natural evolution of the epizootic, we find the microbe becomes attenuated and either finally disappears or, as in plague, persists in chronic form.*

Recrudescence of rat plague in acute form would appear to depend upon the natural infection of fresh generations of rats, the bodies of which are highly susceptible to plague infection.

My observations and knowledge of the habits of rats lead me to the conclusion that the obstinate clinging of plague to any particular area and its periodical recrudescence is occasioned through chronic rat plague. The recrudescence of the epizootic occurs at definite seasons of the year, namely, during the period of maximal rat prolificacy.

WILLIAM HUNTER.

The History of the Course and Relations of Epizootic and Epidemic Plague in the Health Districts of Hongkong during the year 1902.

Introductory Remarks.—Previous to my arrival in Hongkong on the 27th February, 1902, no attempt had been made to thoroughly investigate the course of epizootic plague in rats. From time to time a few rats were examined for the presence of plague infection at the Public Mortuary by the Medical Officer in charge, but these examinations, amounting to a few hundreds only, cannot be regarded as of much value, beyond establishing the fact that such a disease as "Rat Plague" existed in the Colony.

In London, I learned from Professor Simpson, who was about to leave for Hongkong, that much was to be gained by regular and systematic examinations of all rats, dead or alive, and further, his experience of plague in South Africa, pointed to an intimate association between the rat epizootic and the human epidemic.

On my arival in Hongkong, arrangements were made by Professor Simpson and Dr. Clark, the Medical Officer of Health, to have as many rats as possible collected from the various Health Districts of the Colony and forwarded to me for examination.

With the consent of the Principal Civil Medical Officer, I assumed charge of the Government Public Mortuary on the 20th March, 1902.

The rats caught alive or found dead were sent daily to the Public Mortuary.

Exact details as to the place where each rat was found was furnished by the Sanitary Department. During the months of March, April, and part of May, these bacteriological examinations were systematically carried out by myself.

It was evident from the very commencement, however, that if such a research was to be prosecuted on an extensive scale, and in a systematic manner, with uniform result, the accommodation at the Public Mortuary would have to be increased, and extra assistance provided.

Accordingly the existing old Coroner's Court adjoining the Mortuary was so reconstructed that the examination of the animals could be undertaken satisfactorily for the time being. Two rooms were provided—one for actual post-mortem work, the other for microscopic examinations.

Extra assistance was obtained in the month of May. The services of four Japanese Doctors were requisitioned, and the examination of rats was carried on until the month of October.

On the 13th of October, these gentlemen returned to Japan. From this date onwards, the research has been systematically carried on by myself, assisted by Chinese Doctors and Students trained in Western Medicine in the College of Medicine in Hongkong. The opportunities afforded for carrying out these examinations, the bacteriological methods employed, and a short resumé of the results obtained, have already been given in my Report for 1902.

During the year 1902, 117,839 rats, alive or dead, were bacteriologically examined. Of these, 2,015 were found to be plague infected. The number of rats examined daily, counting six days to a week, averaged nearly four hundred.

Charts are attached, representing in the form of curves, the courses taken by the epizootic and the epidemic. In all charts, the epizootic is marked by an uninterrupted line; the epidemic by a dotted line.

As considerable difficulty was experienced in starting the systematic examinations, reliable results were not obtained until the beginning of April. All the charts for 1902, show the start of the curves from the 8th of April. The charts are representative of weekly fluctuations in the epizootic and epidemic. My reasons for dealing with the prevalence of the epizootic and epidemic in each district, and in such detail, is that in a general and annual chart many important points bearing upon the intimate relationship between rat and human plague, become lost or obscured.

WILLIAM HUNTER.

A General Resumé of the Results obtained during 1902.

The results which have been obtained through following the courses of the epizootic and the epidemic, are surprisingly good when one considers the circumstances under which they were obtained.

The research had just been commenced. Difficulties were met with in regard to reliable systematic bacteriological examinations, the routine collection of rats, and the many other duties connected with plague work during the year. With Professor Simpson in the Colony, a large amount of experimental plague work was undertaken, and this in conjunction with my routine duties, partly interfered with the attention which had to be devoted to my investigation into the relations existing between epizootic plague and epidemic plague.

Considerable success, however, was met with, and, notwithstanding the frequent changes in the subordinate staff of examiners, results have been obtained which are, in my opinion, of great value.

The details in regard to rat and human plague are furnished for each Health District in Hongkong. At first it was my intention to confine my researches to a general chart, but on preparation of this, I was so struck by the results obtained, that it was considered necessary to examine the question more thoroughly. Accordingly, charts of each individual district in Hongkong were prepared, and the outcome has been most satisfactory. The more intimate connections between the courses of rat and human plague have been determined in the presence of few numbers. In the majority of the charts, the results are of a very convincing nature. In one or two, the curves are somewhat erratic in their course, but, as can be seen from examination, this is due to the small number of cases which were at disposal. Again, variations in the collections of rats throughout the city have to be accounted for.

Further the rat content of certain districts is subject to variation, according to the sudden advent of a few cases of human plague, which results in sanitary activity being concentrated more or less on this spot for the time being.

Some of the curves would appear to be influenced in this way. The epizootic and epidemic die down, one or other may even disappear.

When such has occurred it will be seen that in these temporarily plague freed areas, *the epizootic is the first to make its reappearance, and the rat plague is followed by a recurrence of human plague within a week or a fortnight.*

It has been said that one or other of these outbreaks may disappear. The lessons which one learns from these curves are that it is possible to have an absolute disappearance of the epidemic.

Sanitary efforts appear so far to be highly successful in regard to the removal of human plague. With the epizootic, the matter is unfortunately otherwise. A survey of the curves will show a drop of the epidemic to zero. The epizootic falls at the same time. The fall may be considerable, but it rarely reaches zero.

These results impress upon us the fact that it is the infected rat which we have to cope with, and that no matter how far reaching our cleansing operations and "stamping out system" of human plague benefit us, the root of the evil still remains in the shape of infected rats.

Among the Health Districts of Hongkong, it would appear that the sanitary success obtainable in any one district is in a great measure vitiated by the condition of affairs in neighbouring districts. One district may be thoroughly cleansed and freed from all plague infection, yet in the course of a few days, such labour and expense are lost, owing to the incoming infection which possibly exists in the immediate surroundings.

Viewing, in the first place, the general chart for 1902, it strikes one that some possible connection exists between rat plague and human plague.

The epizootic is much in excess of the epidemic. Fluctuations in the one are followed by fluctuations in the other.

The epizootic appears in advance of the epidemic. An interval of a week or a fortnight usually elapses. So far as the results of the general chart for 1902 are concerned, it would be a mistake to hastily conclude that the one is the cause of the other—that rat plague is the cause of human plague.

I approached the subject for 1902 with a perfectly open mind. I was quite prepared to find rat plague had nothing to do with human plague, and would not have been surprised to find man the cause of the epizootic.

The general chart shows us then, that *there is a geral resemblance of the epidemic curve to that of the epizootic.* The only thng which strikes one is that it *commences a week later*, and that rises and falls in the epizootic curve are usually followed by similar fluctuations in the epidemic curve. In fact the number of acute rises in the epizootic curve is frequently followed by a similar number of rises in the epidemic curve.

This is certainly true of the earlier stages of outbreak. In order to examine more closely the course and relations of such curves it will be advisable to divide these up into different stages:—

(1.) The Initial stage.
(2.) The Fastigium.
(3.) The Defervescence.
(4.) The Subsequent history of the curves.

The Initial Stage of the Epizootic.—In all the districts of Hongkong the epizootic was existent on the 8th April. Only two districts form the exception, in which its onset was unexplainably delayed, namely, in districts Nos. 5 and 10. In these the epizootic appeared in the middle of April.

For the year 1902, owing the fact that the examinations were not commenced until the beginning of April, it is impossible to say more than that rat plague was existent. It was apparent that in some districts, the epizootic was present for some considerable time previous to the commencement of the examinations. In others, however, it was certainly absent.

The initial rise in rat plague is usually a rapid one. It commences with two, four, or six cases in one week. The number is doubled or tripled during the next week, and the maximum of the epizootic is usually reached in about a month or six weeks after its commencement.

Such is the ordinary course of rat plague. Minor differences are found on going into detail, some of which are interesting.

Exception may be taken to the condition of affairs in district No. 3. The small number of cases of the epizootic and the epidemic during the initial stages, coupled with the preliminary organisation of the rat collecting staff must be held accountable for any apparent discrepancies. In district No. 4, the initial height of the epizootic reached its maximum within the month. A slight fall then took place, concurrently with a fall in the epidemic. This was succeeded by a second maximum in the height of the epizootic, which was reached exactly two months after the commencement of the outbreak.

A somewhat similar condition of affairs is found in districts Nos. 6 and 9.

The rise in the epizootic may be sudden, or by a series of weekly elevations. Sudden advents of rat plague are most frequently found. Gradual elevations with intervening depressions are not common. In general the epizootic reaches a much higher level than the epidemic. In a few instances, the height of the latter approaches that of the former, but this is rare, so far as 1902 is concerned. In districts Nos. 9 and 10, both reach approximately the same level. In districts Nos. 5 and 6, this is also marked, but not to the same degree.

1a. The Initial Stage of the Epidemic.—In the general curve for Hongkong, there is a general rise to the maximal point. The epizootic curve reached its maximum within 5 weeks. *The epidemic curve* followed closely behind, reaching its maximum in 7 weeks, *e.g., a fortnight later than rat plague.* In contradistinction to the curve of the epizootic, the rise in human plague is accomplished by a series of elevations, followed usually by slight depressions. An explanation of this is by no means obvious. Comparisons made with the rat plague curve, show elevations in the epidemic curve subsequent to a distinct rise in the epizootic.

Such elevations in human plague occur usually within a week or fortnight after the rise in epizootic plague. When we study the curves as detailed for each individual district, certain variations are found which give us a considerable amount of information in regard to the possible inter-relationship.

An examination of the Kowloon curve shows us how closely it resembles the general curve of Hongkong. The apex of the epidemic curve is reached a fortnight later than the maximum of the epizootic tracing. A break in the initial stage of the epidemic curve is observable. On looking for similar evidence in that of the epizootic, we find it in the shape of an elevation followed by a depression occurring about a fortnight earlier.

Very satisfactory curves are obtained in Districts Nos. 2, 5, 9 and 10.

In No. 2 the epidemic curve is broken and only reaches its maximum a week after the epizootic has risen beyond what to begin with looked like its ultimate maximum.

In No. 5 the epidemic curve appeared to be following the epizootic closely. The latter reached its maximum but fell suddenly. This sudden fall apparently had the effect of prolonging the low elevation of the epidemic curve even causing a slight depression. Subsequently the severe infection raised the epidemic, and the curve reached its maximum about a month after that of the epizootic.

The picture shown us by Districts Nos. 9 and 10 could not be finer. The rise of the epidemic in both is gradual. The apex of the curve in both is reached a fortnight later than that of the epizootic.

In that of No. 9 the elevations and depressions in the epidemic curve compare admirably with all the variations found in the epizootic curve.

One would almost *imagine* that the second curve in its rise and fall, is *too good to be true. Such an epidemic curve*, occurring ten days or a fortnight after that of the epizootic, is, in my opinion, *strong evidence of some extremely close relation existing between rat plague and human plague.*

In District No. 10, the condition is almost identical. A rather unexplainable fall in the epidemic curve occurs. This may be due to sanitary interference or to the fact that such cases as were present, cleared out of Hongkong as soon as the district became suspiciously plague infected. Such variations in the curves must occur and are impossible to clear up, when one has to fight for knowledge amongst natives, who frequently turn their densest ear towards one, whenever information regarding cases of suspicious sickness is requested.

Other variations in the epidemic curve are forthcoming in Districts Nos. 6 and 8. Here the elevation to the maximum of the epidemic is certainly postponed for a considerable time.

It is difficult to account for such, but on going into the question with such detail as I have done, in the presence of a native population, and rigorous sanitary measures, it is surprising to find so many of the charts which give accurate information in regard to the incidence of the epizootic and the epidemic. In the remaining districts the maximum elevation of the epidemic curve was low, notwithstanding an occasional appreciable elevation in the curve of the epizootic. A close examination of the relation of the epidemic curve to that of the epizootic will enable one to conclude that the course of the epizootic curve is in the majority of instances responsible for the shape of the epidemic curve.

The Fastigium.—In the general curve for 1902, a good idea is obtained of what holds good of or each individual district, in regard to the maintenance of the elevation of the epizootic and the epidemic. *The sudden rise of the epizootic to its maximum is not usually long maintained.* A fall for some considerable distance takes place, with a subsequent maintanance of a lowered elevation for some weeks. *The epidemic in general shows the same character.*

The general curves for each individual district show practically the same as that which obtains in the general curve. The elevations and depressions at and about the maximal extent of each curve follow each other closely. The same close relation between human and rat plague is shown during this stage of the outbreaks.

The Defervescent of the Curves.—In order to bring the epidemic curve into close relation with that of the epizootic, *this part of the outbreak is of the highest importance.*

We have seen so far that ascent, and maximal elevation with variations, the two curves follow each other closely.

From this alone one could not claim to have established a connection between the two outbreaks, all one could say is that both occur about the same time, but probably occur quite independently of each other, at least the question would be asked, given these two curves, the one as it were lying within the other, what points in these lead on to the conclusion that the one is the result of the other.

The history of the outbreaks is useful. We have seen that the epizootic precedes the epidemic by about a fortnight, that variations in the epizootic are followed by variations in the epidemic, that their maximal point more or less correspond, and in general, a superficial glance at the curves makes one think of the extremely close relation which must exist between the two outbreaks.

But it must be remembered, that rat plague may be present without the advent of human plague, and *vice versa*, and that *occasionally the amount of rat plague bears no relation to the amount of human plague.* These questions and others must be answered before accepting the statement that in rats we have the key to the problem of plague prevention.

The general curve for 1902 shows the epidemic curve almost surrounded by that of the epizootic. From this chart alone it could not be concluded that the one is the cause of the other, if so, we should expect the rat plague curve to fall inside that of the epidemic curve. Shortly, if there is a connection between the epizootic and the epidemic, the latter should rise according to the elevations in the epizootic, and with a fall in the epizootic, human plague should more or less cease.

The preliminary part of these curves have been followed. They are seen more or less to harmonise. The point now to be considered is the relation existing between *the epidemic* and *the epizootic* towards the close of the outbreaks. *If the latter is the cause of the former it should fall previous to the decline in epidemic plague.*

There are other considerations which must be brought forward, which do show the close inter-relationship between rat and human plague. It will be of interest, however, to examine as to how far this question may be answered affirmatively. In the general chart, the rat plague curve has just missed falling inside that of the epidemic. Here, however, we are dealing with an extremely mixed collection of results. The condition of affairs in each individual district is of much greater interest.

In order to show the relationship between the fall of the two curves, *it is necessary to have a sufficient complement of epizootic and epidemic.* As we have seen, the epizootic is usually in excess. The number of cases of the epidemic may be so small as to vitiate what would otherwise have been a positive result.

Therefore in drawing conclusions as to this point only charts showing a goodly number of both outbreaks in fairly equal proportion can be used.

The Kowloon chart like the general chart (which also includes Kowloon) shows a very large preponderance of the epizootic. A close examination of the two curves, however, will convince one that had the epidemic been in anything like proportionate numbers, its defervescence would have followed and not immediately preceded that of the epizootic.

The experience gained in other districts is of the greatest interest in this respect.

In all the districts in Hongkong in 1902, with three exceptions, *the charts show that the epizootic falls first and is followed by the epidemic.* Immediately the *rat plague diminishes or disappears human plague becomes* more or less *extinct.* In order to convince oneself of this, a glance at the charts of Health Districts Nos, 2, 5, 9, and 10 is sufficient. A similar condition of affairs is also to be found in the charts of the Districts Nos. 1, 3, and 6.

The three exceptions mentioned, namely, those found in Districts Nos. 4, 7 and 8, come under the same category as the general chart and that for Kowloon. rat plague is severe, but the epidemic is slight. This being so, an opportunity is not afforded to compare the one curve with the other.

The Subsequent History of the Curves.

Again this is of the greatest interest. Many points are worthy of close study in regard to the continuance or decline of one or other of the outbreaks. The general chart shows us that *the epidemic becomes extinct.* A few cases occur erratically, but no further epidemic takes place.

The epizootic falls and to all appearance looks as if it were to disappear also. This is not so, however; it *never becomes extinct.* It remains in abeyance for a week or two, subsequently breaking out in considerable numbers.

This recrudescence of the epizootic is not followed by the epidemic.

The type of curve of the recrudescent epizootic is totally different from that of the main outbreak. The rises and falls of the curve are gradual not precipitous like the onset and course of the primary curve. This recurrant epizootic is seen to maintain itself in considerable force until the end of the year.

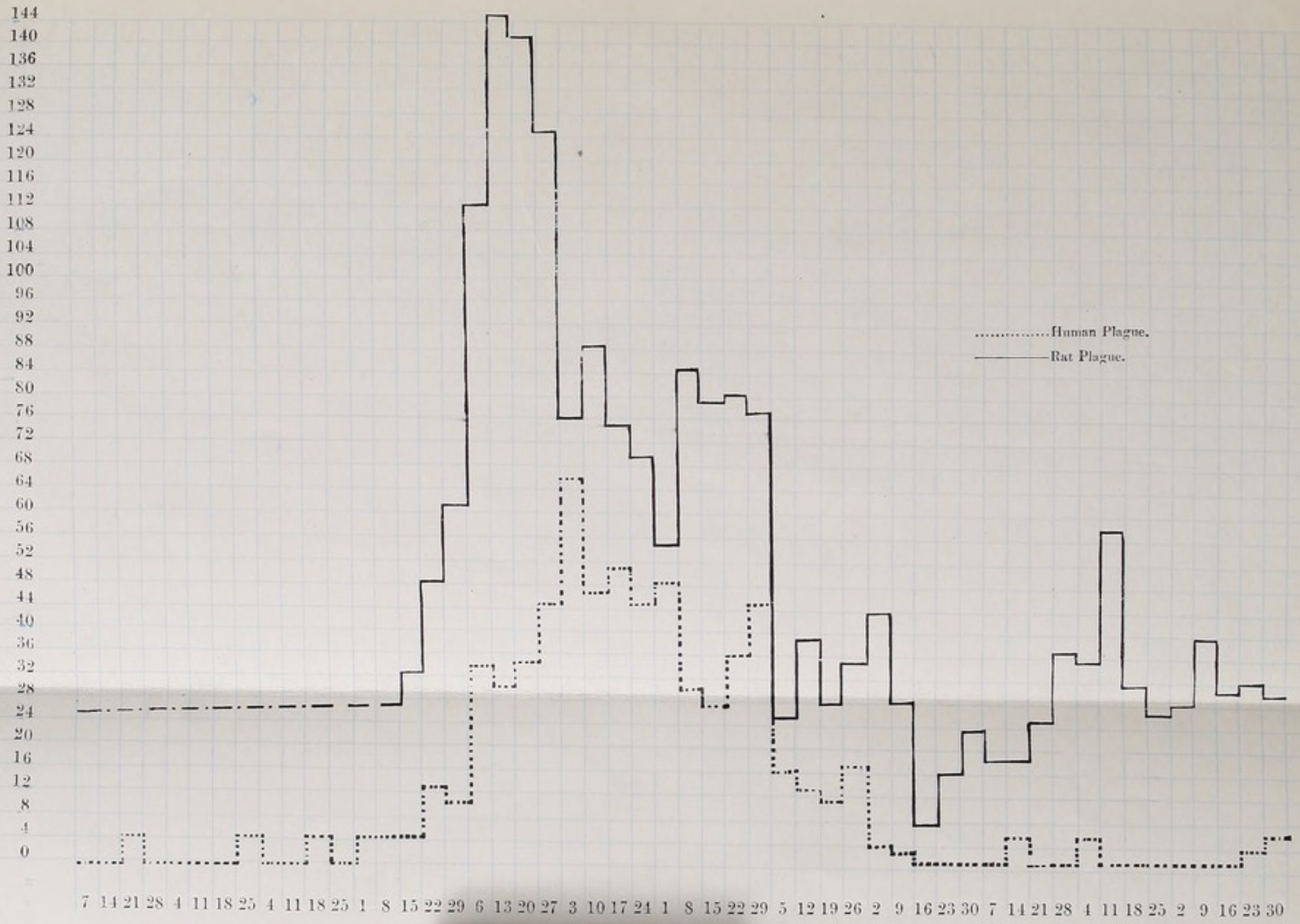
Such a discovery is of great significance in regard to the possible recurrence of the epidemic in the different districts. This part of the epizootic and its significance is considered under a separate heading.

Noteworthy is the severity of the epizootic during the last quarter of 1902 in the following districts: Kowloon Nos. 2, 6, and 8. It will be interesting to follow the course of events in these districts during the early part of 1903, and trace as far as possible the influence of a mild or a severe epizootic towards the end of the year, on the outbreak of the epidemic in these particular districts.

The foregoing represents as shortly as possible a resumé of the results of my investigations into the rat question during 1902.

In my opinion, the results are better than were at first expected. Notwithstanding many initial defects in the whole system of rat examination, the research has brought out many points bearing upon the course of the epizootic and its possible relation to the epidemic.

HONGKONG.—1902.



It was only by continued examination of enormous numbers of rats and careful microscopic and bacteriological methods that these results have been elicited.

Throughout the whole of 1902, I was ably assisted by many willing hands, and my thanks are due to the members of the Sanitary and Medical Departments who have at all times rendered me every assistance possible.

I do not conclude for a moment that all the lessons to be learnt from the accompanying charts are given in my resumé. Perhaps careful examination of these by other observers may lead to new facts and varied interpretations. The results of 1902 are merely put forward as a further link in the already strong chain of evidence in favour of the rat theory of plague.

These observations have been extended throughout the whole of 1903 and part of 1904. These results will be compared with those of 1902, and the sequence of events which happened during the interval between the epidemic of 1902 and 1903, and that between 1903 and 1904 will be shown as clearly as possible.

It is only by such a systematic examination that results of value can be obtained, and these investigations which were begun over two years ago, and have been continued without intermission ever since, ought to enable us to decide, *whether the rat theory is in reality only supposition or is founded upon actual fact.*

WILLIAM HUNTER.

The History of the Colony in 1902.

On this chart, we have, in condensed form, the epizootic and epidemic curves.

We have no reliable data in regard to the presence of rat plague previous to the 8th of April. Cases of the epidemic had occurred from time to time, but in more or less sporadic form.

During the week ending April the 8th, the amount of rat plague was estimated. Human plague was then existent, but the cases were few in number. During the 2nd week of April, the epizootic began to rise. No change in the epidemic was noted during this week.

During the 3rd week of April, the epidemic began to rise.

From this point onwards, both outbreaks increased in severity, the one following the other, the interval being 10 days to a fortnight.

The maximum of rat plague was reached on the week ending the 13th of May.

The maximum of human plague was attained on the week ending the 3rd of June, a little over a fortnight later.

Subsequent to this date, variations in rat plague are followed by variations in the epidemic. Both fall together, the epidemic disappearing gradually. The epizootic, on the other hand, after a pronounced fall, reasserts itself, and runs with a varying severity until the end of the year.

WILLIAM HUNTER.

The History of Health District No. 1 in 1902.

The history commences from the 8th of April. Rat plague is already existent on the 8th of April, but is slight in amount.

So far it has not been accompanied by epidemic plague. A fortnight later a considerable rise in rat plague takes place, succeeded by a fall in about a week later. *A week or ten days after this initial rise in rat plague, human plague appears.*

The course of the epidemic curve follows closely that of the epizootic curve. It is only delayed about 14 days. A second rise in the epizootic takes place in May towards the end of the month.

This is succeeded by a reappearance of the epidemic during the first and second weeks of June. Subsequent to this date, a peculiar alteration of circumstances takes place.

Up to the middle of June, the epizootic has always preceded the epidemic by about a fortnight.

Subsequent to this period, a complete overthrowal of the order of events takes place.

The epidemic does not vanish in a week or two after the fall in epizootic plague. Cases frequently occur, maintaining the human plague curve above that of the epizootic.

The rat plague becomes extinct for a week in the presence of human plague.

In a week or so, rat plague reappears as pronounced as ever. By this time human plague has disappeared for a week. But after this recrudescence of rat plague has lasted a week, human plague reappears and persists for a week subsequent to the disappearance of the epizootic recrudescence. A week later rat plague again appears but is not followed by any marked epidemic. Subsequently brief outbursts of the epizootic occur during the last quarter of the year. No epidemic occurs. A possible explanation of this, will be given under a separate heading.

The Conclusions drawn from District No. 1.

1. The epizootic preceded the epidemic at the beginning.
2. The interval between both averages a fortnight.
3. Towards the middle of the epidemic, the continued elevation of the human plague curve, would appear to occasion an elevation of the epizootic curve, the latter again calling forth a recrudescence of the epidemic.
4. The recrudescence of the epidemic would again occasion an outbreak of the epizootic, etc.
5. The curves show that during the early stages of the epizootic and epidemic, rat plague and human plague are distinct. The former is regularly succeeded by the latter. During the height of both each would appear to occasion the other. The epidemic may occasion the epizootic, the latter again stimulating the advent of the epidemic.
6. The commencement of the epidemic would appear to be the result of the epizootic.
7. During the height of the disease, the epidemic and the epizootic would appear to share equally the continuance of the disease.

The History of Health District No. 2 in 1902.

On the 8th of April, the epizootic is thoroughly established and maintains itself until the end of May. No epidemic was existent on the 8th of April. *It appeared a fortnight later.*

With the continued rise in the epizootic during this period, the epidemic was established. *The epidemic reaches its highest point one week after the apex of the epizootic.*

Towards the end of May both fall. The epizootic becomes extinct. The epidemic falls slightly, and subsequently rises to nearly its former height. As already mentioned, there is no rat plague at this period.

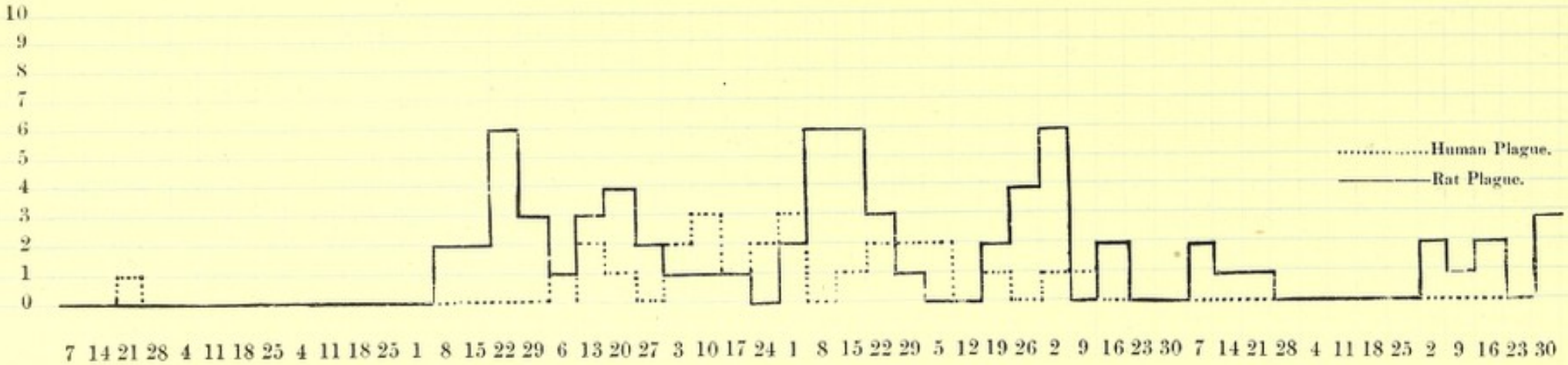
The epidemic now continues more or less constantly. This being so, the epizootic reappears, gradually rising to a higher level than the epidemic. Subsequently the epidemic would appear to follow the epizootic and *vice versa*. The epidemic stopped on the 26th of August. The epizootic continued more or less throughout the year.

A rise in the epizootic towards the end of the year is well marked.

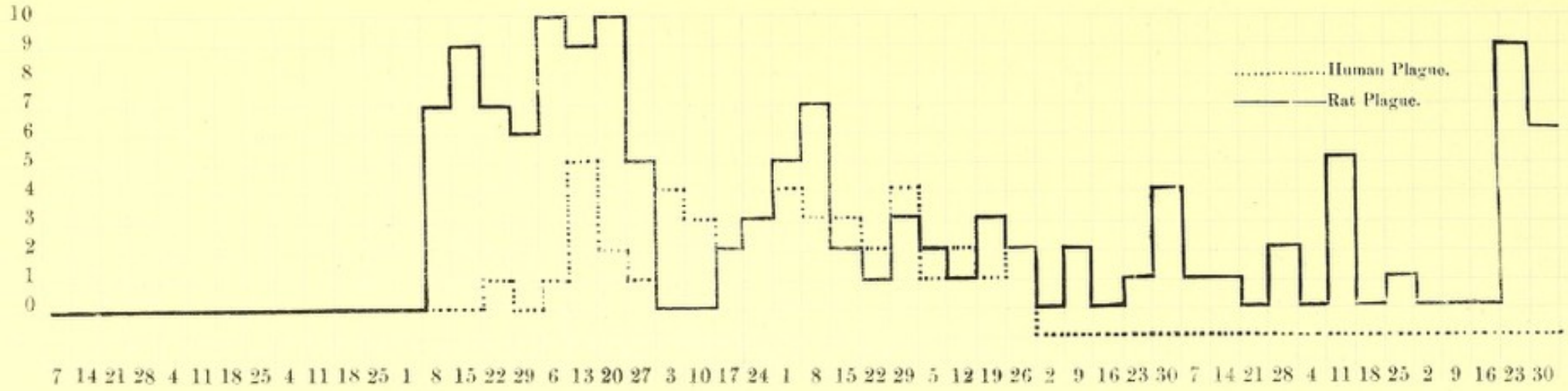
Conclusions drawn from District No. 2.—

1. The course of the disease is an excellent example of the relationship between the epidemic and the epizootic.

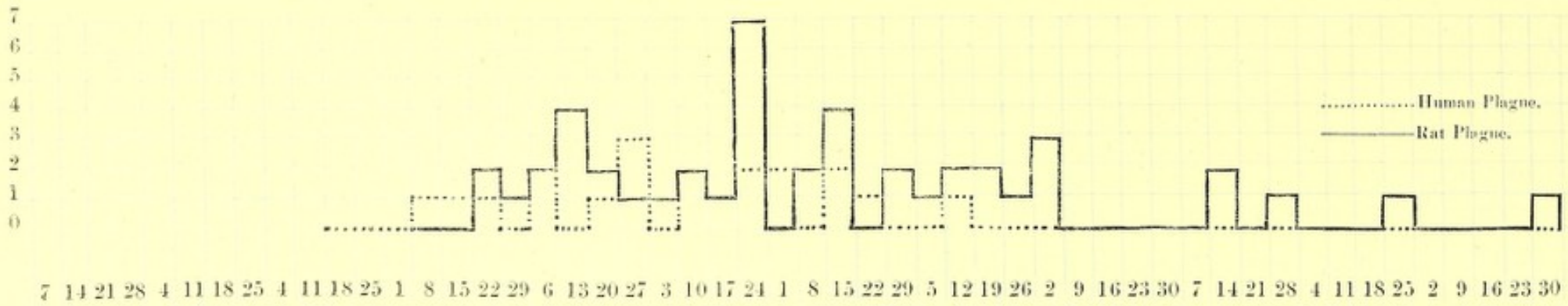
HONGKONG DISTRICT No. 1.–1902.



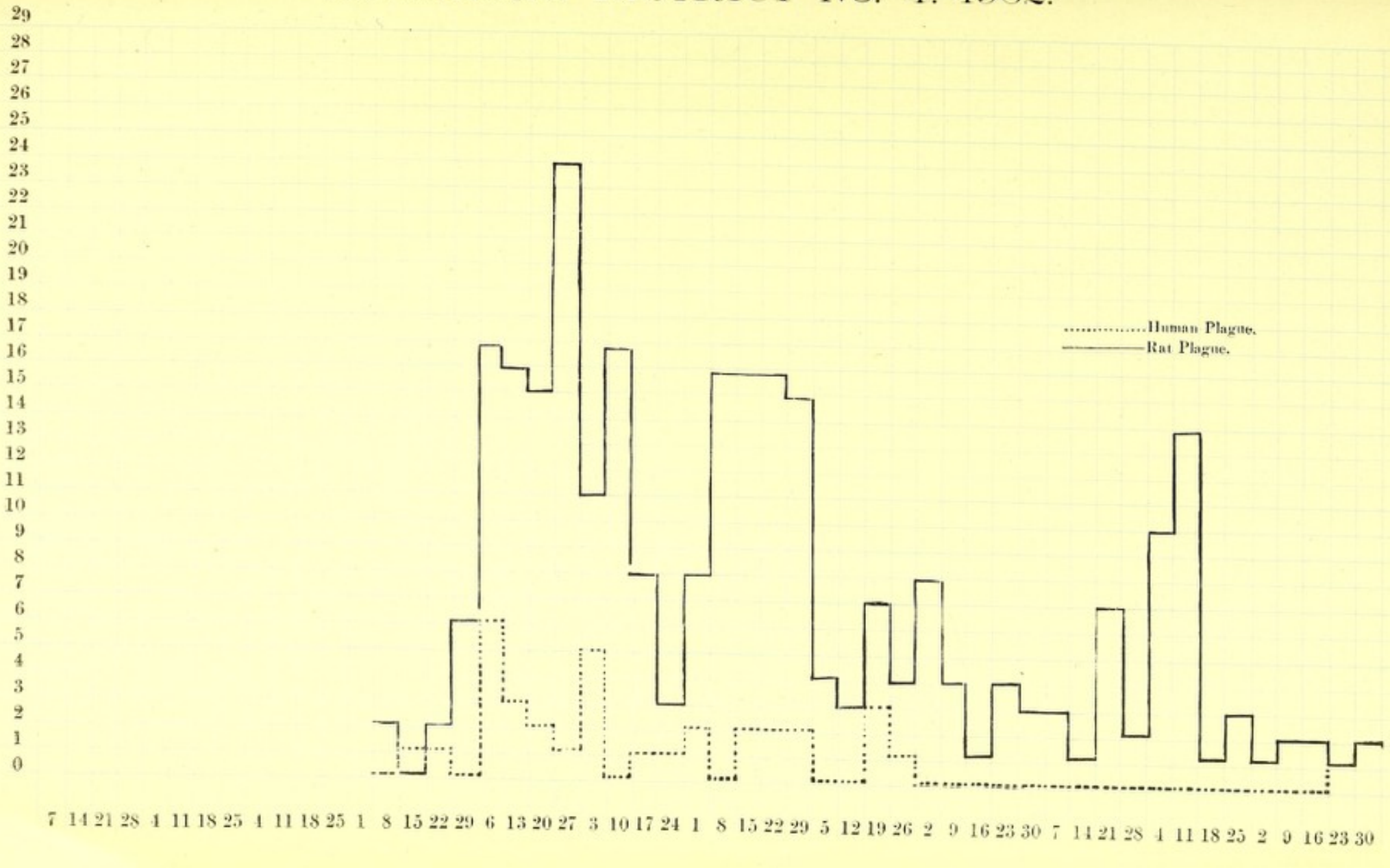
HONGKONG DISTRICT No. 2.—1902.



HONGKONG DISTRICT No. 3.–1902.



HONGKONG DISTRICT NO. 4.—1902.



2. The epidemic appears about 14 days after the epizootic.
3. Its height is reached about a week after the epizootic reaches its maximum.
4. The epizootic disappears, while the epidemic continues.
5. The inter-relationship of the epizootic and epidemic during the height of the disease.

The History of Health District No. 3 in 1902.—The epizootic was existent on the 8th April.

The epidemic did not appear until 14 days later.

During May the epidemic appears to follow the epizootic.

A rise in the epizootic during the first fortnight of May, is succeeded by a rise in the epidemic during the last two weeks of May.

During the height of the disease, a close relationship exists between the epizootic and epidemic.

This chart, generally taken, shows the same characters as in that of Districts Nos. 1 and 2.

It must be remembered that this District was very slightly affected during 1902, making the construction of curves extremely difficult, and the small number of cases renders an interpretation of the curves almost impossible. A comparison with the state of affairs found in other districts, clarifies the course of events found in 1902 in this District.

The History of Health District No. 4.—On the 8th of April, the epizootic was present. No epidemic present.

A week later, the epidemic appeared. The epizootic rose during the 4th week of April. The epidemic rose during the 1st week of May. The epizootic reached its maximum during the 4th week of May. This was followed by a sudden rise in the epidemic during the 1st week of June.

The epizootic fell greatly in numbers during the last week of June.

The epidemic disappeared during the 2nd week of July. The epizootic rose again to a height during the 1st, 2nd and 3rd weeks of July.

The epidemic reappeared for 3 weeks, namely, during the 2nd, 3rd and 4th weeks of July. Subsequently the epidemic disappeared until the end of the year.

The epizootic continued with exacerbations throughout the remainder of the year.

Conclusions drawn from District No. 4.—

1. The appearance of the epidemic is a week later than the epizootic.
2. A rise in epizootic plague is followed by a rise in epidemic plague.
3. A fall in epizootic plague is followed by a fall in epidemic plague.
4. The epizootic may exist rampant without the epidemic. This would appear possible only at certain periods of the year, namely, during the last quarter.

The History of Health District No. 5.—The epizootic and epidemic were late in appearance.

Rat plague appeared in the middle of April. Human plague appeared on the first of May. The general course of the disease showed an acute exacerbation of the epizootic with a more or less rapid fall.

The epidemic increased gradually, reaching its height four weeks after the maximum of the epizootic.

At the time the epidemic was at its height, the epizootic had diminished greatly. The epidemic disappeared within a week, and was followed by a recrudescence of the epizootic. This increase of rat plague was not followed by a great recrudescence of human plague. Cases of human plague were present, but few in number.

The epizootic with exacerbations continued to the end of the year. Human plague was practically absent.

Conclusions drawn from District No. 5.—

1. The primary severe epizootic was followed by a severe outbreak of the epidemic.
2. The epidemic reached its maximum after a fall in the numbers of the epizootic.
3. Little or no relation appears to exist between human plague and the continuance, with acute outbreaks, of the epizootic.

The History of Health District No. 6 in 1902.—Rat plague appeared on the 8th of April.

The epidemic followed a fortnight later. The courses of the epizootic and epidemic are somewhat similar to that found in Health District No. 5.

In the middle of May the epizootic reached its highest point.

At the beginning of June, a smart rise of the epidemic was found.

During the first week of July a sudden rise of the epidemic took place, and this was followed by a rise in the epizootic which was prolonged for several weeks.

The condition of affairs is representative of what is usually found, and compares favourably with the charts illustrating the sequence of events in other districts. Noteworthy is the continuance of rat plague until the end of the year. Possible explanation of this rise of the epizootic is given under a separate heading.

The History of Health District No. 7 in 1902.—The epizootic was present on the 8th of April. The epidemic started a fortnight later. The highest point in the epizootic was reached about the middle of the month of May. The highest point in the epidemic was reached about the first week in the month of June, *i.e.*, about a fortnight later.

A regular rise and fall of the epizootic and the epidemic took place throughout. In general a rise in rat plague was followed by a rise in human plague about ten days to a fortnight later. A point of note in connection with the epizootic is the repeated acute recrudescence of the disease. In this chart, as well as in many others, one finds two main recrudescences of the epizootic during the prevalence of the epidemic. Sudden outbursts of the epizootic without the advent of human plague are found, as in other districts, towards the end of the year.

The History of Health District No. 8 in 1902.—The epizootic was present on the 8th of April, but remained in abeyance until about the end of the month.

During the week ending the 29th April, there was a sudden advent of rat plague. This was followed a week later by the appearance of the epidemic. During the week ending the 6th May, the epizootic reached its maximum height. From this date onwards with various depressions and exacerbations, the epizootic curve slowly fell, coming more or less suddenly to an end about the middle of September.

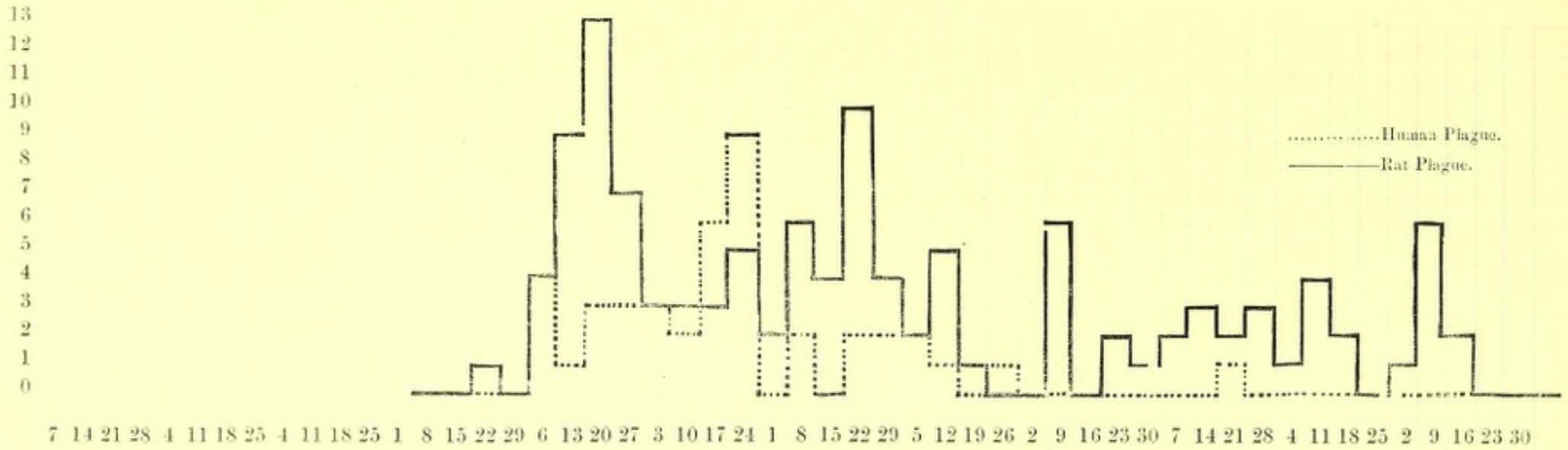
Human plague evidenced itself during the greater part of the period of the epizootic. It began a week later, had exacerbations and depressions more or less similar to those found in the epizootic, and it finished a fortnight previous to rat plague. The more minute details in regard to the two curves compare favourably with those already given under other districts.

Conclusions drawn from this District.—

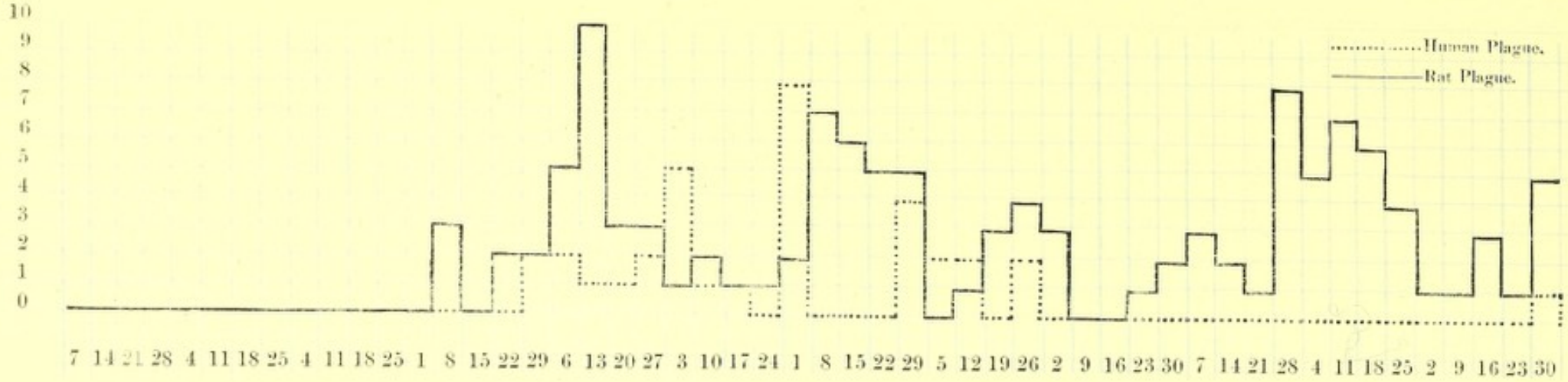
1. The epizootic is sudden in advent.
2. The epidemic is more gradual in onsets.
3. The epizootic begins one week earlier and finishes a fortnight later than the epidemic.

The History of Health District No. 9 in 1902.—So far as the relations existing between the epizootic and the epidemic, *this district is of the greatest importance.*

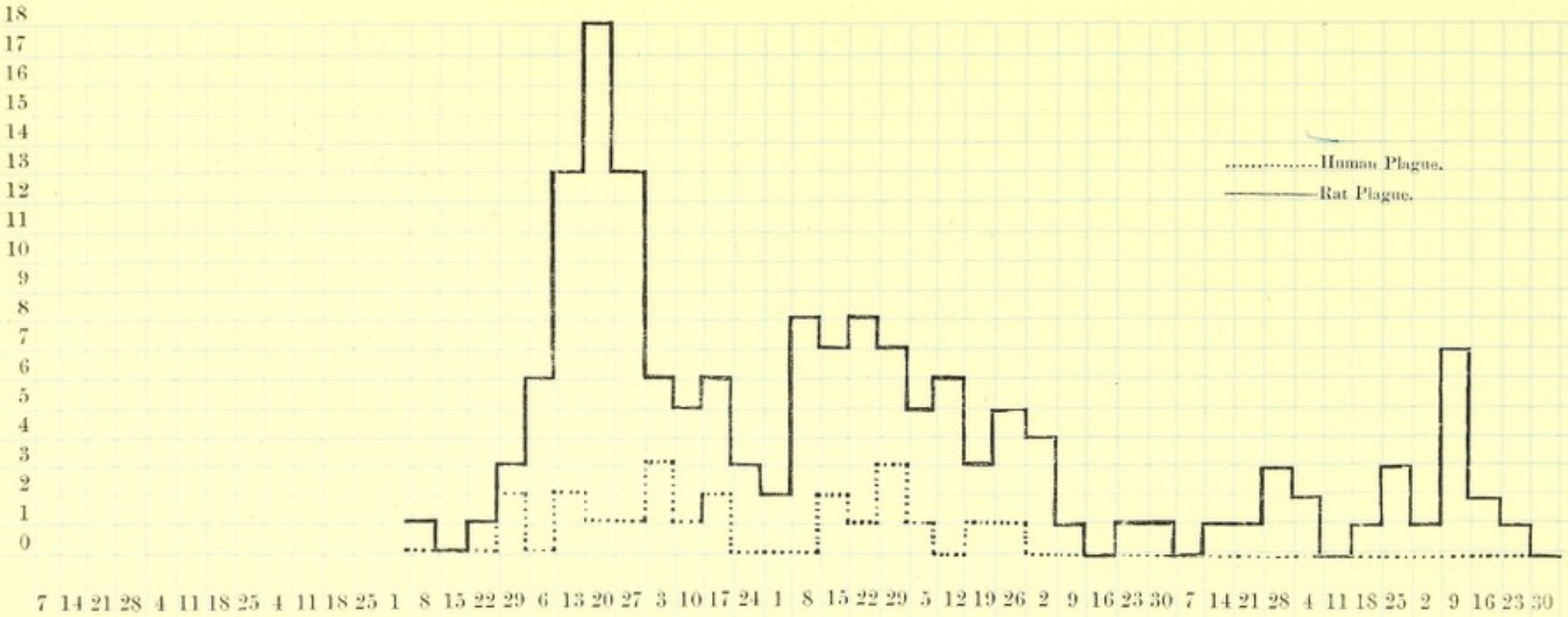
HONGKONG DISTRICT No. 5.–1902.



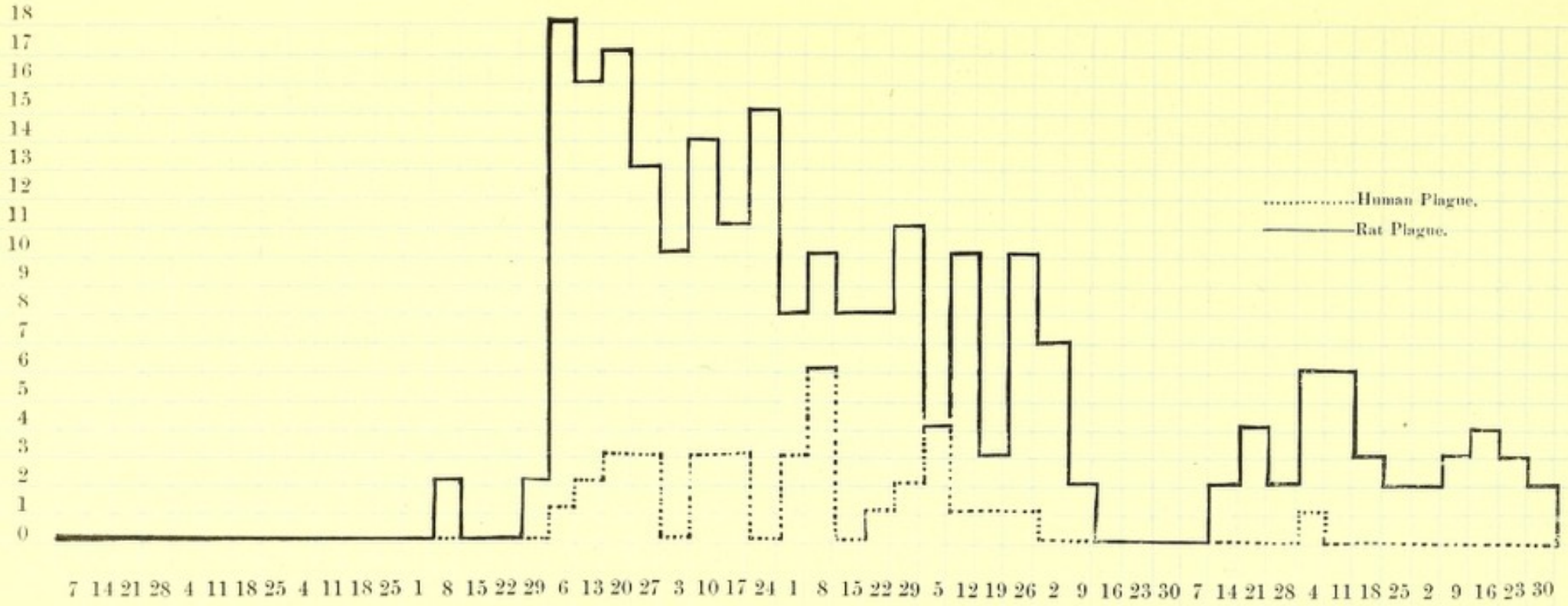
HONGKONG DISTRICT No. 6.–1902.



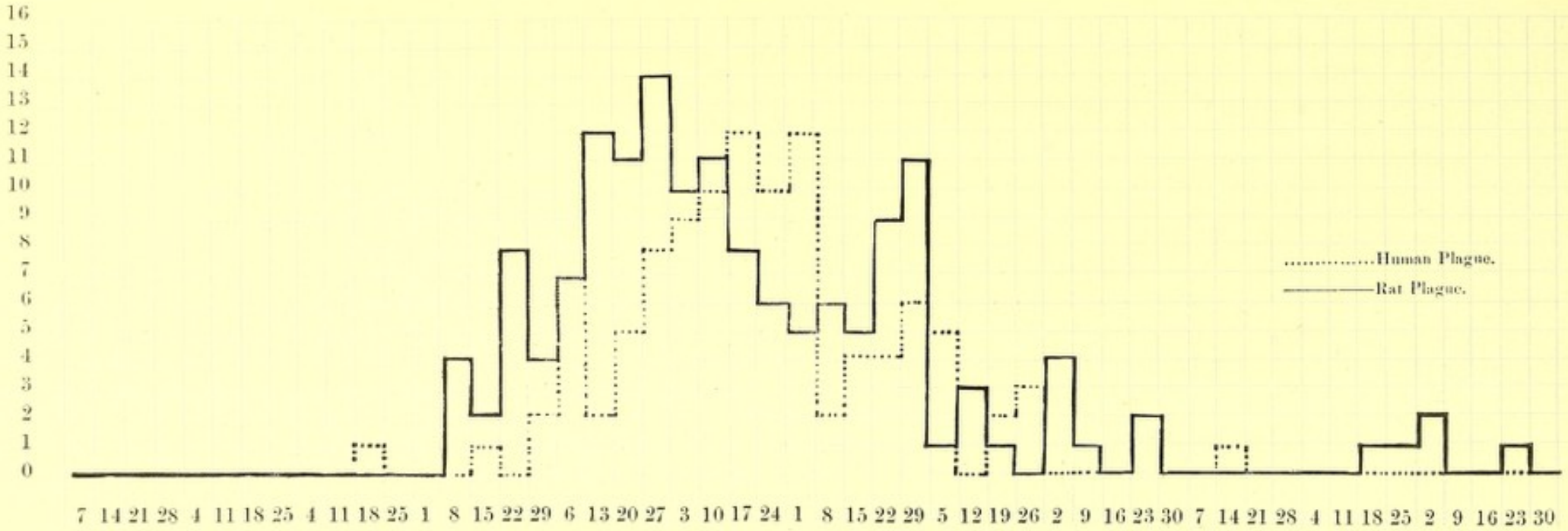
HONGKONG DISTRICT No. 7.—1902.



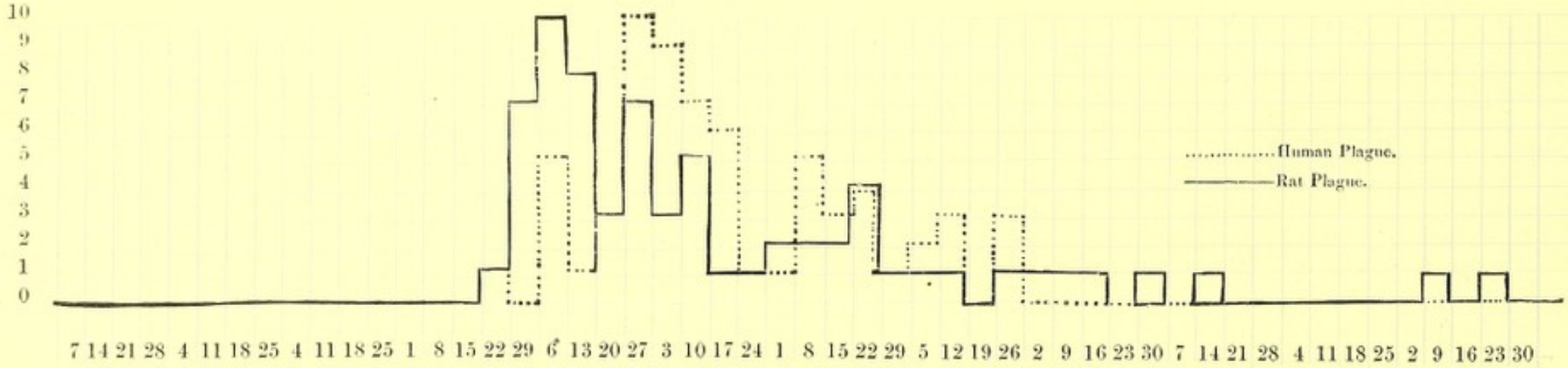
HONGKONG DISTRICT NO. 8.–1902.



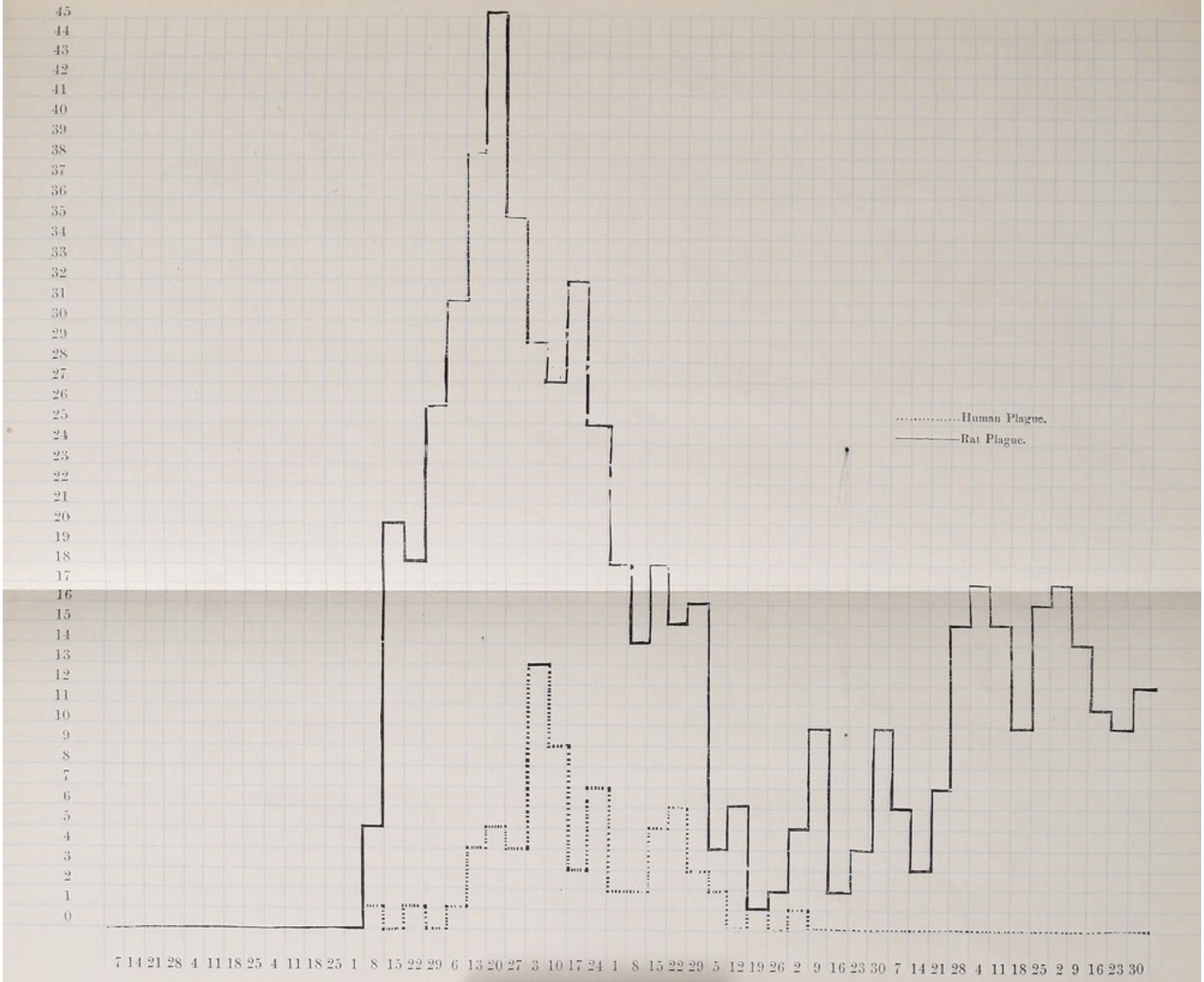
HONGKONG DISTRICT No. 9.–1902.



HONGKONG DISTRICT No. 10.–1902.



HONGKONG-KOWLOON—1902.



A study of the chart is most instructive. The epizootic started on the 8th of April. The epidemic began on the 15th of April. A regular rise in the epizootic is followed by a similar rise in the epidemic about a week or ten days later.

The epizootic reaches its maximum a fortnight before the highest point in the curve of the epidemic. The fall in rat plague occurs previous to the fall in human plague.

During the month of July another recrudescence of rat and human plague took place. The relations existing between the two are the same as those already mentioned.

During the month of August a close inter-relationship existed between rat and human plague.

Conclusions drawn from District No. 9.—

1. The epizootic preceded the epidemic by one week.
2. The epidemic increased in proportion to the epizootic.
3. Both diminished in proportion.
4. A relapse occurred in both cases with similar results.
5. From this chart, it would appear that the epidemic stands in direct relation to the epizootic. *With an increased epizootic, one obtains an increased epidemic and vice versa.*

The History of Health District No. 10 in 1902.—A general survey of the two curves in this district is, in my opinion, of a very convincing nature in regard to the relationship existing between the epizootic and the epidemic.

The epizootic is first in the field. It is followed by the epidemic, the march of which is at first sight slower.

Notwithstanding, the epidemic reaches its maximum about a fortnight after the climax of the epizootic. Both fall gradually, the epizootic first in order. From the month of July onwards, recrudescences of both outbreaks take place from time to time. This is in harmony with the results obtained in other districts. A possible explanation of this will be brought forward later.

Conclusions drawn from this District.—

1. The epidemic follows the epizootic with an interval varying from 7 to 14 days.
2. The detail in the epidemic is apparently moulded by that of the epizootic.
3. Characteristic is the fall of the epidemic in accordance with the decline in rat plague.

The History of Kowloon in 1902.—The district is an extremely large one, and the results which I have obtained on comparing the epidemic with the epizootic, give one practically the same picture as obtained on preparing a general chart for Hongkong.

The general chart of Hongkong for 1902 is almost identical with this one.

My intention was to deal with Kowloon in a similar manner to Hongkong, but, being single handed, and pressed for time, I found the labour too great.

Doubtless if the details of Kowloon were given, the results would compare favourably with those obtained for each individual district in Hongkong. Such curves as these, when placed alongside many of those prepared for single districts, show us how carefully the question of inter-relationship of epizootic and epidemic must be approached. General curves give us a fair survery of what is at work, but it is only on thoroughly going into each district in detail, that the closer relations between the two outbreaks become evident.

A glance at these curves of Kowloon show us the great preponderance of the epizootic. Yet notwithstanding, the epidemic follows, in its rise and fall, the course of the rat plague, showing the usual interval between the occurrence of the one and the appearance of the other. *Of great interest is the severity of the epizootic during the last quarter of the year.*

The History of the Course and Relations of Epizootic and Epidemic Plague in the Health Districts of Hongkong during the year 1903.

In dealing with the subject of rat and human plague for the year 1903, the descriptions of the epizootic and the epidemic merely require to be touched. The details given under the History of the 1903 outbreak conform more or less to those found during 1902.

Much greater reliance is to be placed upon these results. The observations were made after the system of rat collection and examination had been more or less perfected. Certain errors which were brought to light during the year have been eliminated as far as possible. These are, mainly, the possible importation of dead and living rats into the Colony by the Chinese who evidently believed that fortunes were about to be amassed by the sale of rats to innocent coolies at the expense of the Government. This factor in the system of rat collection was fortunately soon discovered and rigorously dealt with by the Sanitary Authorities.

In the preparation of the curves for 1903, this falsifying of the rat return has been remedied as far as possible. It would not appear to have altered the condition of affairs to any great extent as can be seen by comparing the charts with those of 1902.

A factor in determining the relationship of epidemic plague to the epizootic was noted in the resumé for 1902, namely, the number of cases of both outbreaks at one's disposal. Obviously the epidemic of 1902 occasionally failed me in producing a sufficient number of plague cases in certain districts in the epidemic of 1903. On the other hand, the epizootic exceeds the epidemic in number of cases so greatly that, in certain charts, it is difficult to trace much connection between the curves.

Comparisons made with the charts of 1902 will clarify matters considerably.

Again the charts for 1903 have in their favour the determination of the amounts of both epizootic and epidemic throughout the whole year.

There are many points of considerable importance in regard to the behaviour of the epizootic during the interval between two epidemics. The influences exerted by the epizootic in determining the amount and the distribution of the succeeding epidemic, etc., are discussed under a separate heading.

The charts are prepared in the same manner as those for 1902. They are in certain instances much more extensive, but this is accounted for by the increased severity of the epizootic and epidemic throughout the year. Attempts were made to reduce the charts, but the result was found unsatisfactory and might possibly lead to certain misinterpretation.

In preparing all the charts, actual numbers have been dealt with.

During the year, 101,056 rats were examined. Of there, 3,744 were found to be infected with plague.

General Resumé of the Results obtained during 1903.—The results obtained during this year are more regular. Some of the greater oscillations in the curve of the epizootic about its maximum are in all probability due to the fraudulent import of rats which was rampant during the height of the plague season. These can be more or less eliminated in comparing the results.

Similar to what was obtained in 1902, sudden variations in the rat content and number of plague infected rats in each district, are found.

Of importance in regard to the early appearance of the epidemic is the presence of a considerable amount of rat plague on the 1st of January. So long as this epizootic maintains its average degree of severity, no cases of human plague are found. Immediately, however, a definite rise of rat plague takes place, cases of plague in man may be expected within a fortnight.

It is a point of considerable interest to find the existence of marked rat plague without the presence of cases in man. The details furnished by the charts of each district are of importance in this respect. It is seen that in some districts the advent of human plague is delayed for some considerable time. The epidemic had by this time made its appearance in Hongkong, but some districts remained free. In these latter districts the curves are interesting. The human plague curve is at zero, and what is of importance, the epizootic may be high but maintains this height with constancy. After a month or two a sudden rise—small or great—in the rat plague curve takes place. What happens now, is the regular appearance of human plague.

On following out these details in each district, one will see that the rat plague becomes epizootic, so to speak, at different times in different districts, and what is so conclusive, in regard to the relation of the one outbreak to the other, is the incidence of human plague at corresponding times in each district. Human plague appears regularly after the occurrence of the epizootic. The interval between the two outbreaks rarely exceed a fortnight. We have therefore in one large city like Hongkong, an epidemic of plague. The city divided into a number of Health Districts. The epidemic is not equally spread over the city. Certain Health Districts are severely affected; in others, the epidemic is non-existent.

Why is this so? Districts may adjoin each other. One may be furnishing human plague; the other may be practically free.

A glance at those charts which have been prepared will help us to settle the question in our minds.

In all districts furnishing human plague, the epizootic is present in great excess, and the epidemic would appear to be proportionate to the epizootic.

In all districts furnishing rat plague—but not an ever-increasing epizootic—human plague is usually absent. One or two cases may occur, but no epidemic breaks out. In any plague rat infected district, an increase in the epizootic means the appearance of human plague. In regard to the 1903 epizootic and epidemic, these conclusions appear to be warranted. The epidemic was a large one, at least for Hongkong; every district was more or less epizootically and epidemically infected.

Similar to the outbreak of 1902, Kowloon was grossly epizootically infected. The epidemic was also more prevalent in this part of the Colony than in any other Health District. With regard to the epizootic, not a single week passed without the occurrence of several cases of rat plague in Kowloon.

A minute examination of the course and relations of the curves would be superfluous. They speak for themselves, and when considered by the examiner in the same way as I have treated those of the 1902 outbreak, become perfectly intelligible.

WILLIAM HUNTER.

The History of Hongkong during 1903.

A very important point in connection with the determination of the relation of the epidemic to the epizootic, is that one is now enabled to follow closely the train of events from the commencement of the year. On the 1st January, 1903, rat plague was existent and constituted more or less of a definite epizootic. On the other hand there was no trace of an epidemic. If reference be made to the curves of the epizootic and epidemic during the last quarter of 1902, it will be seen that the former raged more or less incessantly, whereas the epidemic, apart from one or two sporadic cases of plague, was non-existent. The epizootic maintained an average level of from 20 to 30 cases per week. The epidemic was nil. Such a condition of affairs did not hold good for the commencement of the new year 1903. Almost immediately the epidemic appeared, and subsequently both this and the epizootic ran very characteristic charts.

Within a fortnight of the new year, human plague was present. The commencement of the 3rd week of January marked the advent of the 1903 epidemic of pest.

A careful survey of both curves, namely, that of the epizootic and the epidemic, will enable one to draw their own conclusions. The rises and falls of the epizootic curve are followed only too closely by similar elevations and depressions in the incidence of human plague.

Although rat plague is in excess numerically, yet the tracking of the epidemic in the steps of the epizootic is only too well marked.

Such a following of one curve after another, one observes rarely, and I must confess that it was with much surprise that, subsequent to the preparation of the rat plague curve, the epidemic curve was found to show such similarity. The apices of both curves are found to correspond with the result obtained during 1902. Both reach their highest points within a fortnight of each other, the epizootic first.

The course of events, after the outbreaks have reached their highest figures, is interesting. The epidemic falls in numbers so rapidly, that practically within a month, the number of cases of human plague has fallen to an insignificant figure. But what is even more remarkable, is the sudden drop in the epizootic. It maintains its elevated position for about a fortnight after the depression of the epidemic, and then, for some reason, suddenly drops.

The time occupied by the epizootic in falling from its maximum to its lowest level is about 15 weeks. The epidemic took about 13 weeks, namely, about a fortnight shorter.

The subsequent history of the curves is not so interesting. Rat plague never disappears. Human plague is practically absent.

This interval between the incidence of human and rat plague appears to be more or less constant. In 1902 the interval between the occurrence of both outbreaks was from 10 days to a fortnight The course of events during 1903 leads us to the same conclusion in regard to the time limit.

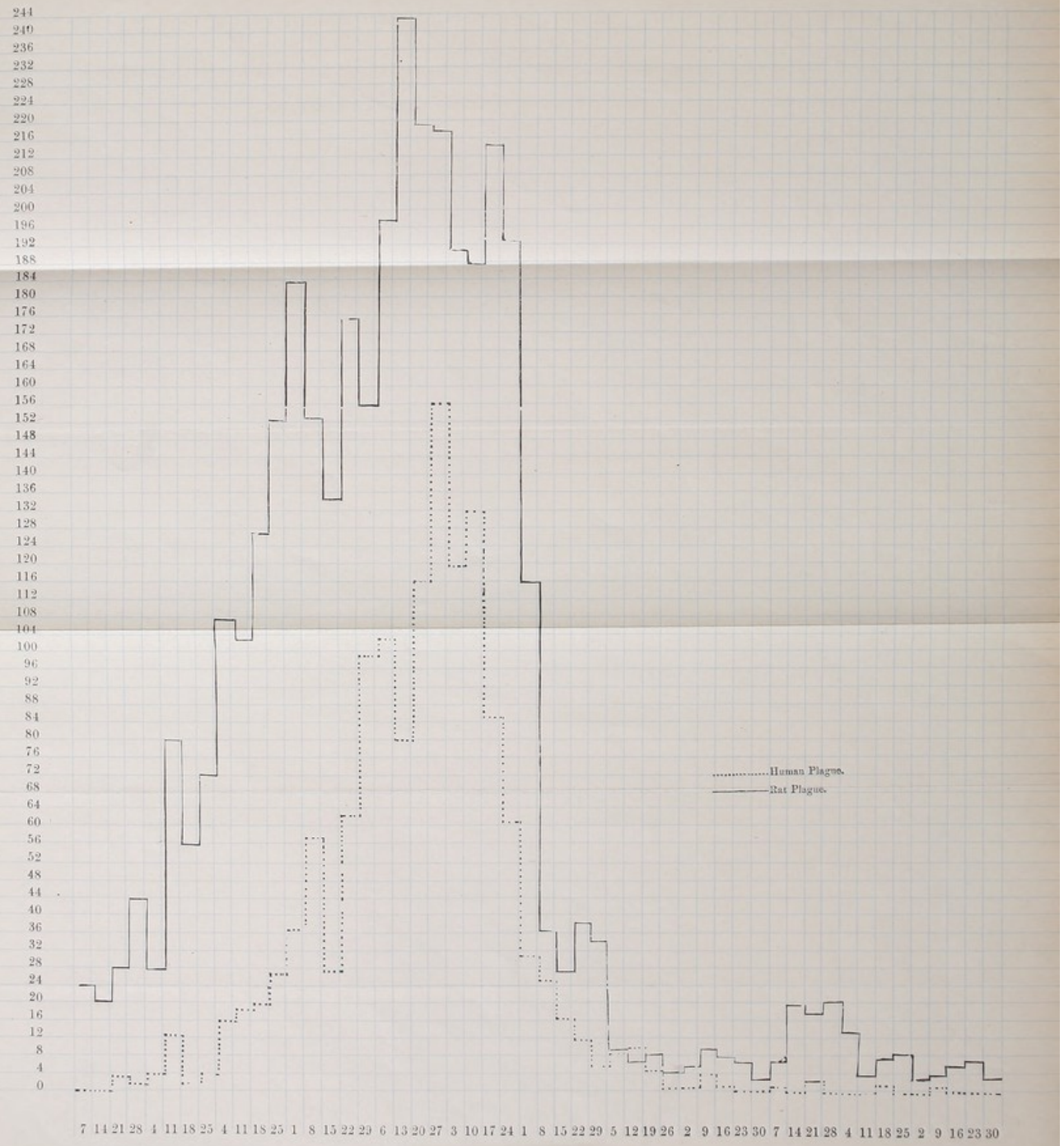
Compared with the epizootic the epidemic begins a fortnight later, it reaches its maximum a fortnight later, the maximum is maintained for a similar length of time and its fall occupies practically 14 days. Subsequently it disappears, whereas the epizootic maintains a low but certain level.

One would expect the fall in rat plague to occur somewhat previous to that of the epidemic. The condition of affair is, however, practically a repetition of what took place during 1902. A study of these outbreaks in each individual district teaches us that such is frequently found. Summing up these two curves, the conclusion which one must necessarily draw, are, *that human plague commences immediately after the increased incident of the epizootic*, and that variations in the latter occasion variations in the former. Such is true until the apices of both curves are reached. Subsequent to this period, the epidemic falls rapidly, and has reached a low l-vel previous to great alterations in the incidence for about a fortnight after the great depression of the epidemic, then by means of two jumps suddenly drops to practically the same level from which it started at the commencement of the year A close study of such a chart is bound to lead one to think of some relation between the two outbreaks. It may be said that both run independently of each other, only the epidemic appears about a fortnight later. It would be difficult to imagine such a regular system in the incidence of an infectious disease when compared with an epizootic. We can imagine the epidemic of plague commencing practically at the same season during each year, but that it should regularly appear within a definite incubation period after the advent of the epizootic is difficult to get away from, unless we admit of the existence of a definite relationship. Again it is found that the plague epidemic does not commence at a definite period during each year. In 1902, it was not present until the middle of April. In 1903 it began in the middle of January or at least by the 1st of February. In 1904 its commencement was even later than during 1902.

Let one now compare the epizootic during these years. In 1902, the epizootic began about the 1st of April. In 1903, rat plague began a fortnight earlier than human plague, namely, during the middle of January.

In 1904, it will be found that a similar condition of affairs was present.

HONGKONG–1903.



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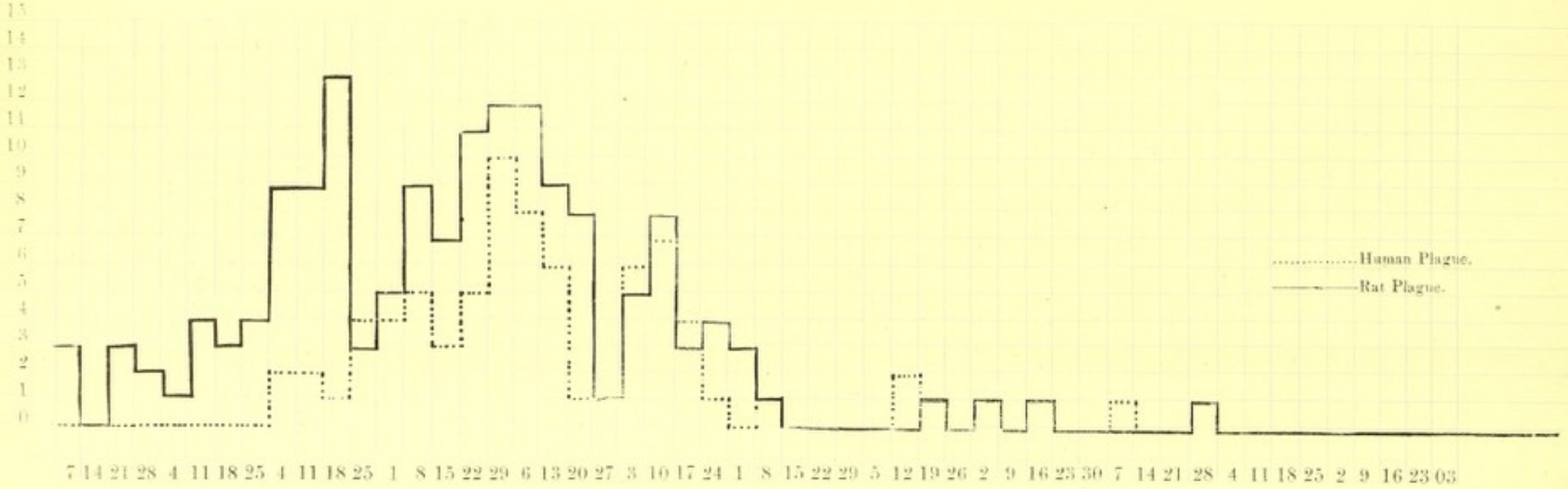

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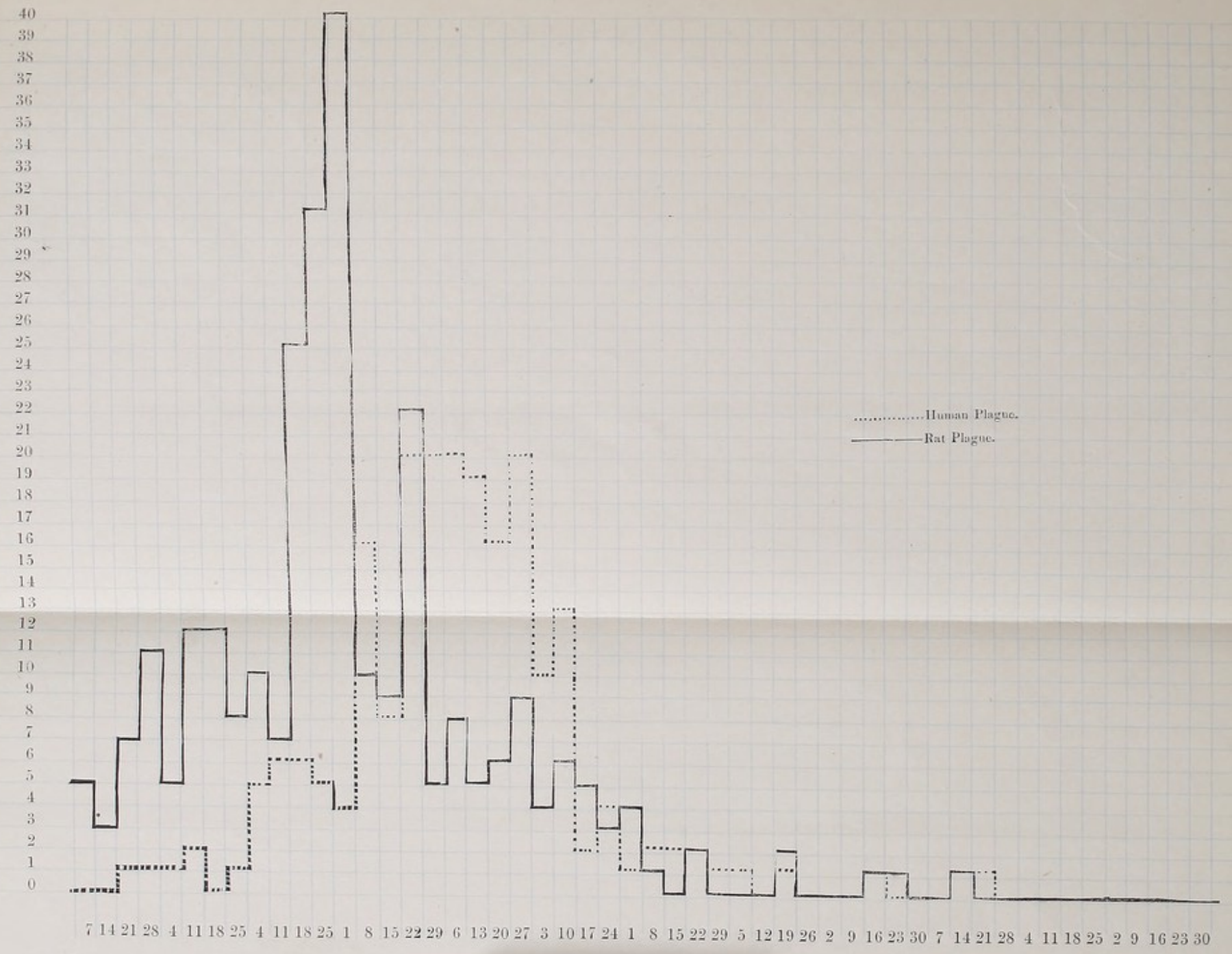

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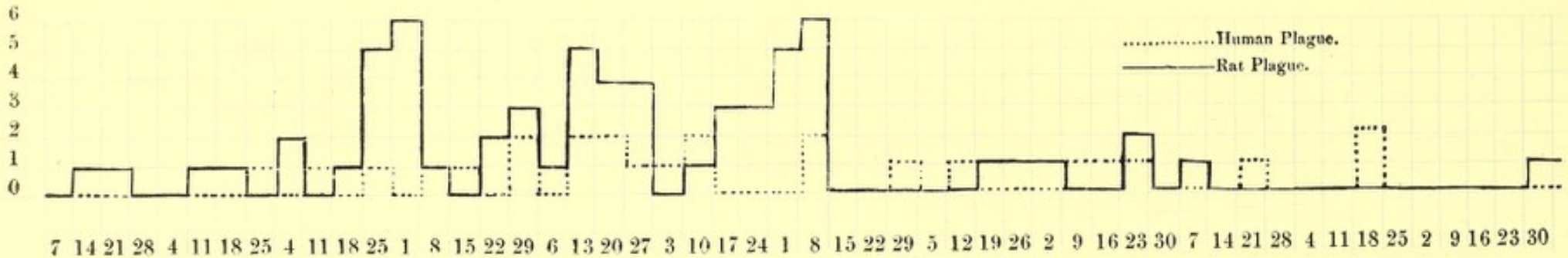

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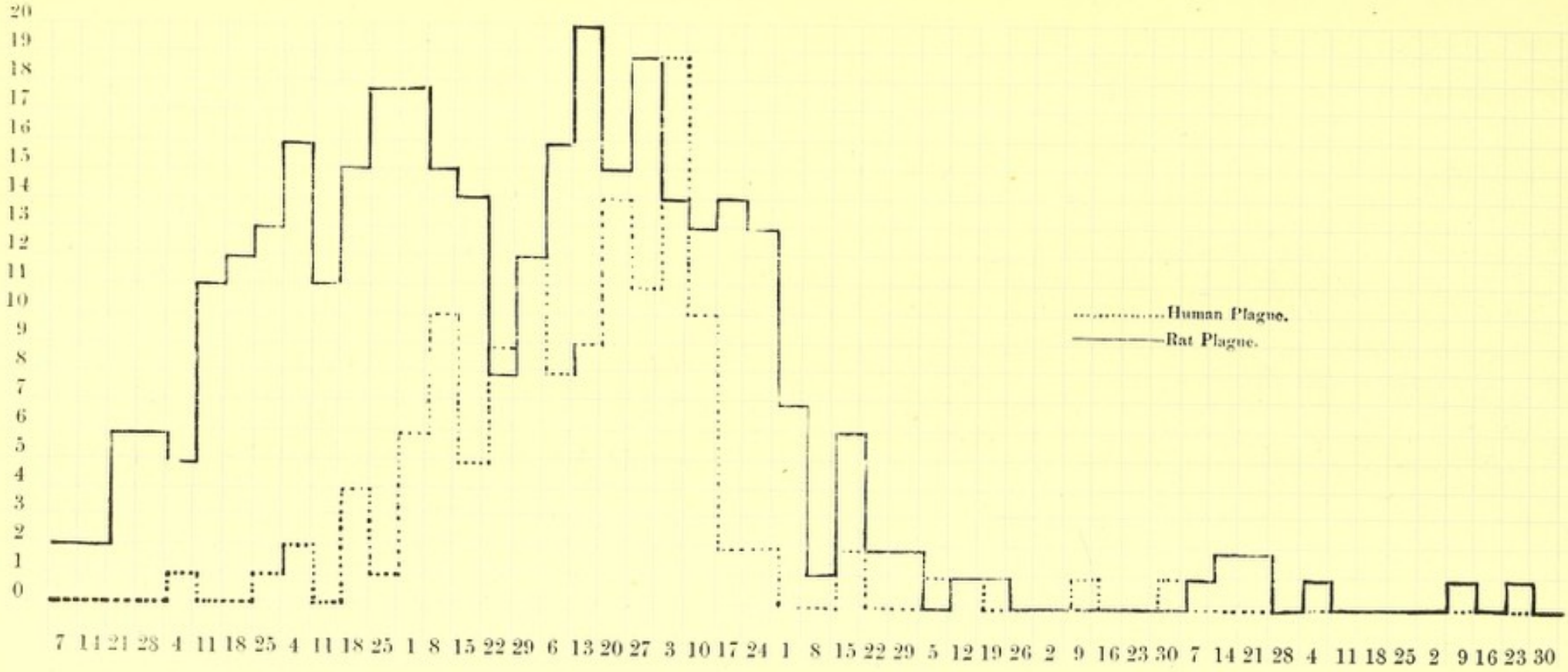

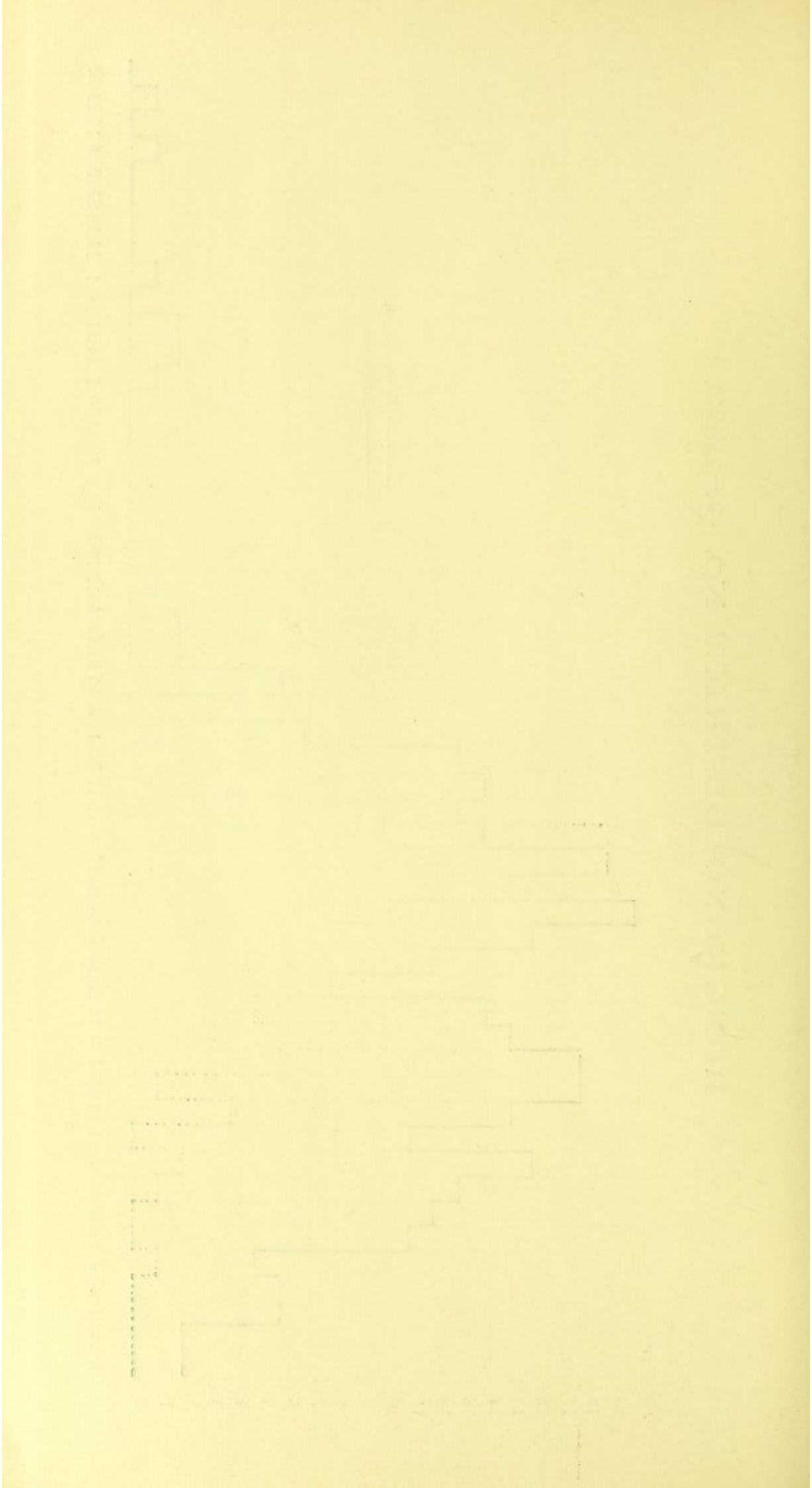

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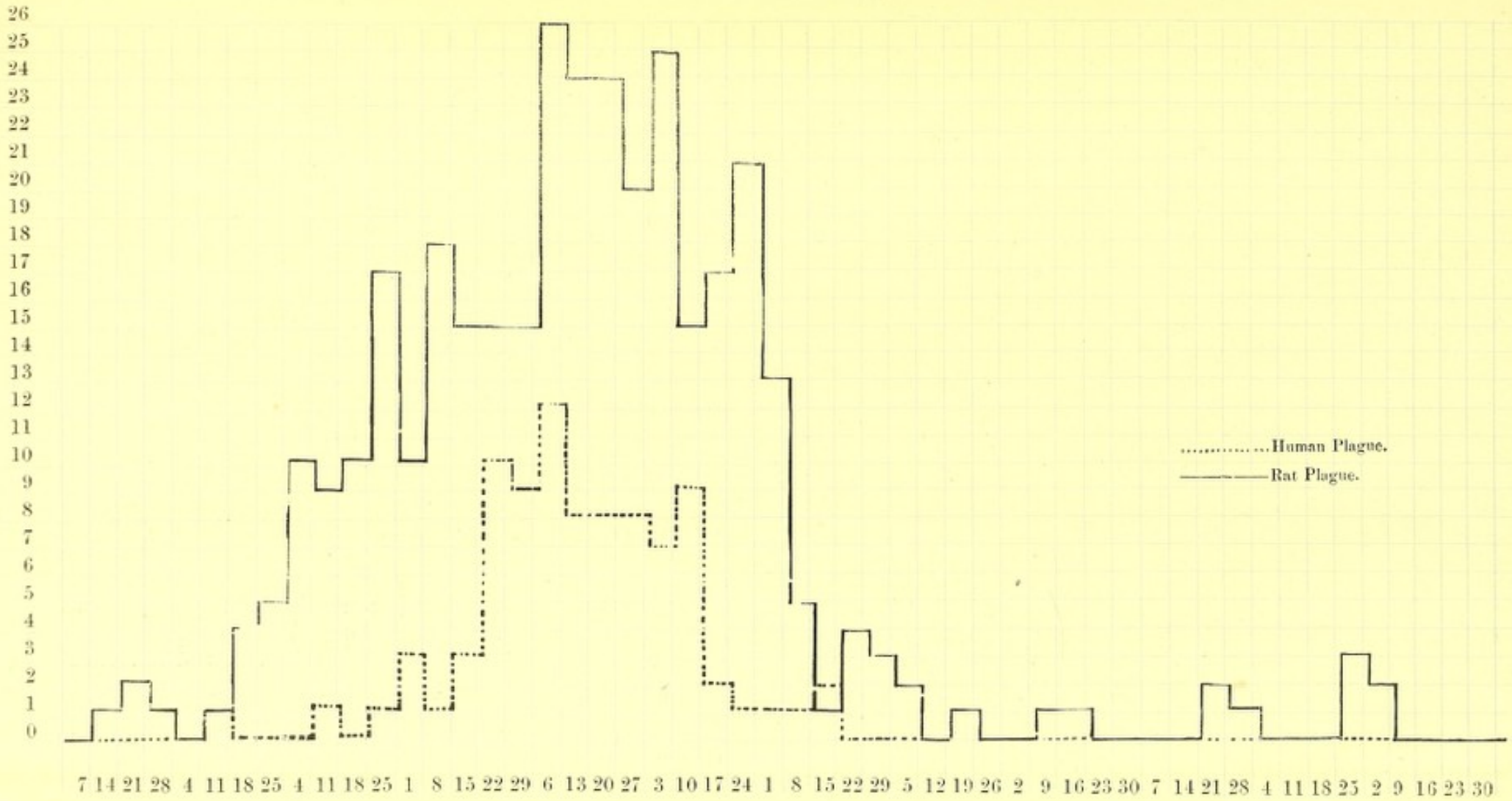

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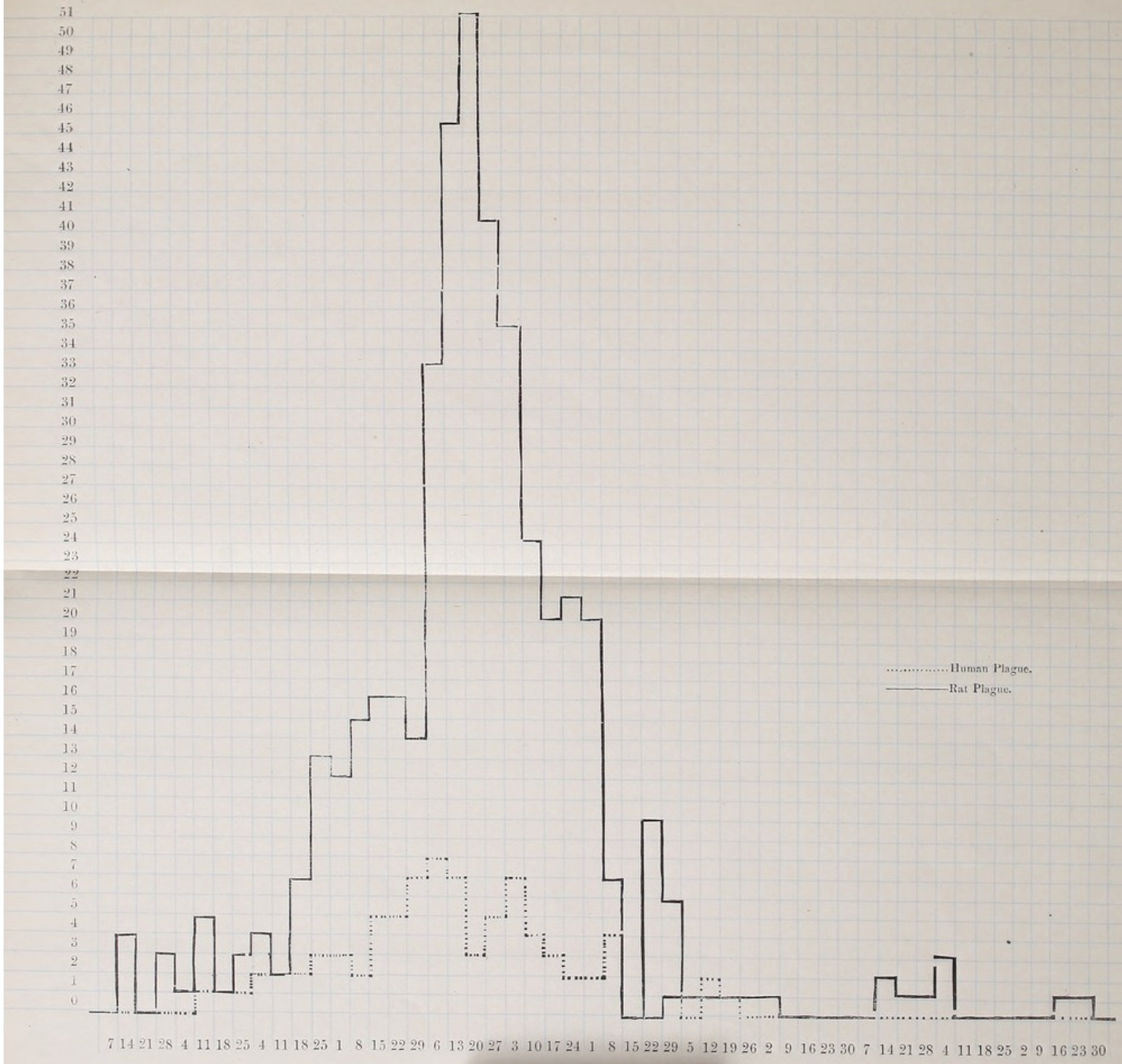

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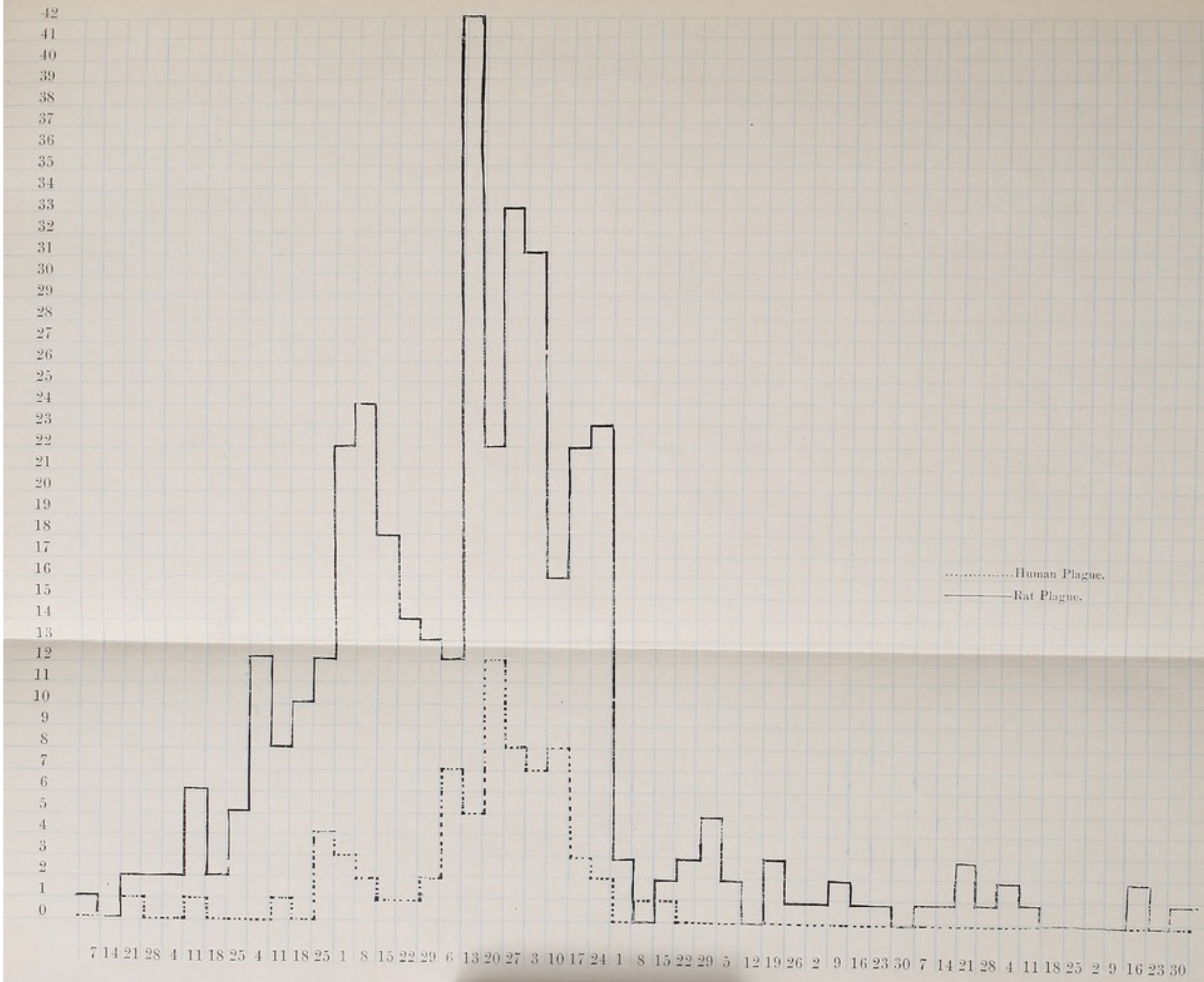
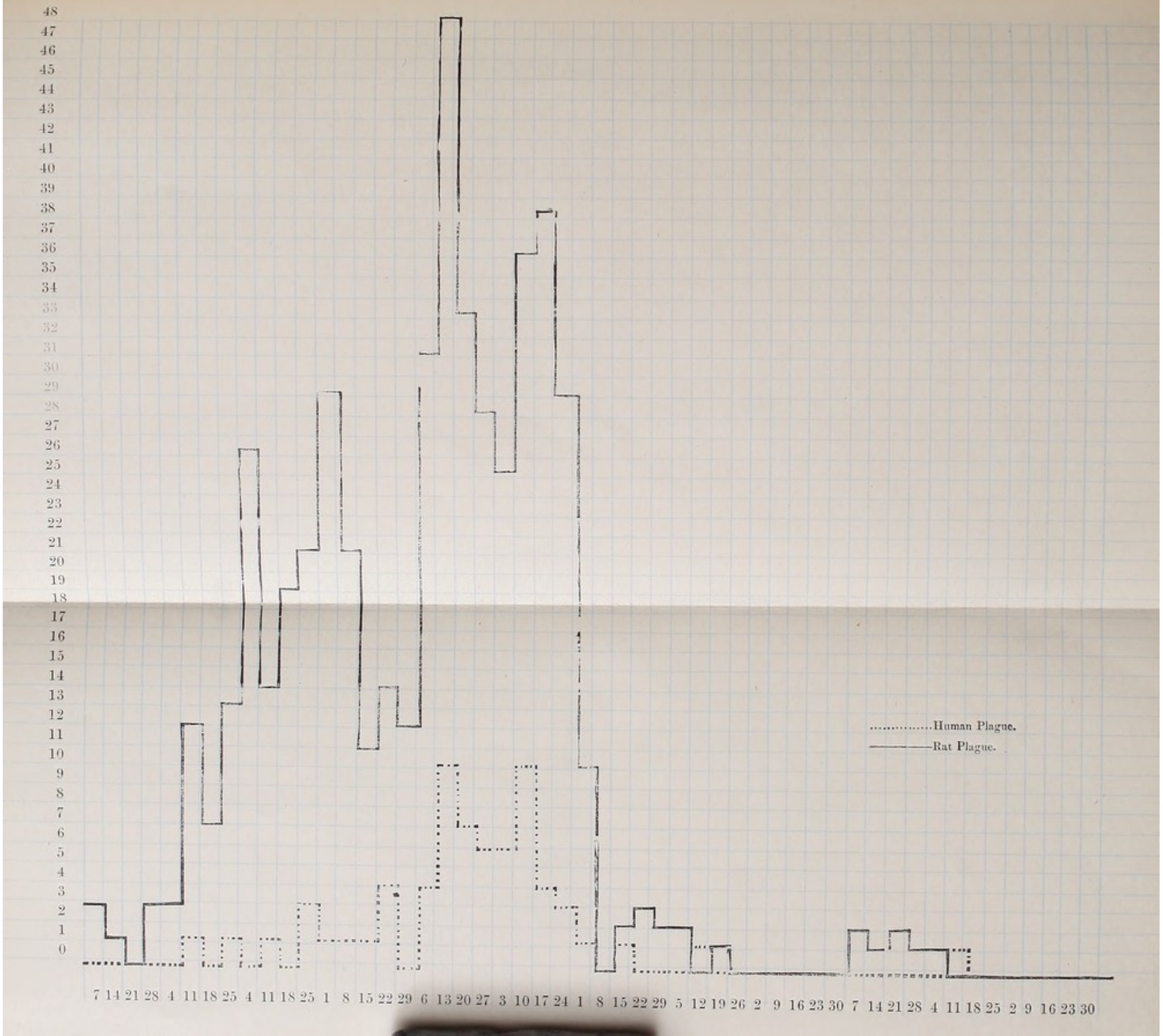
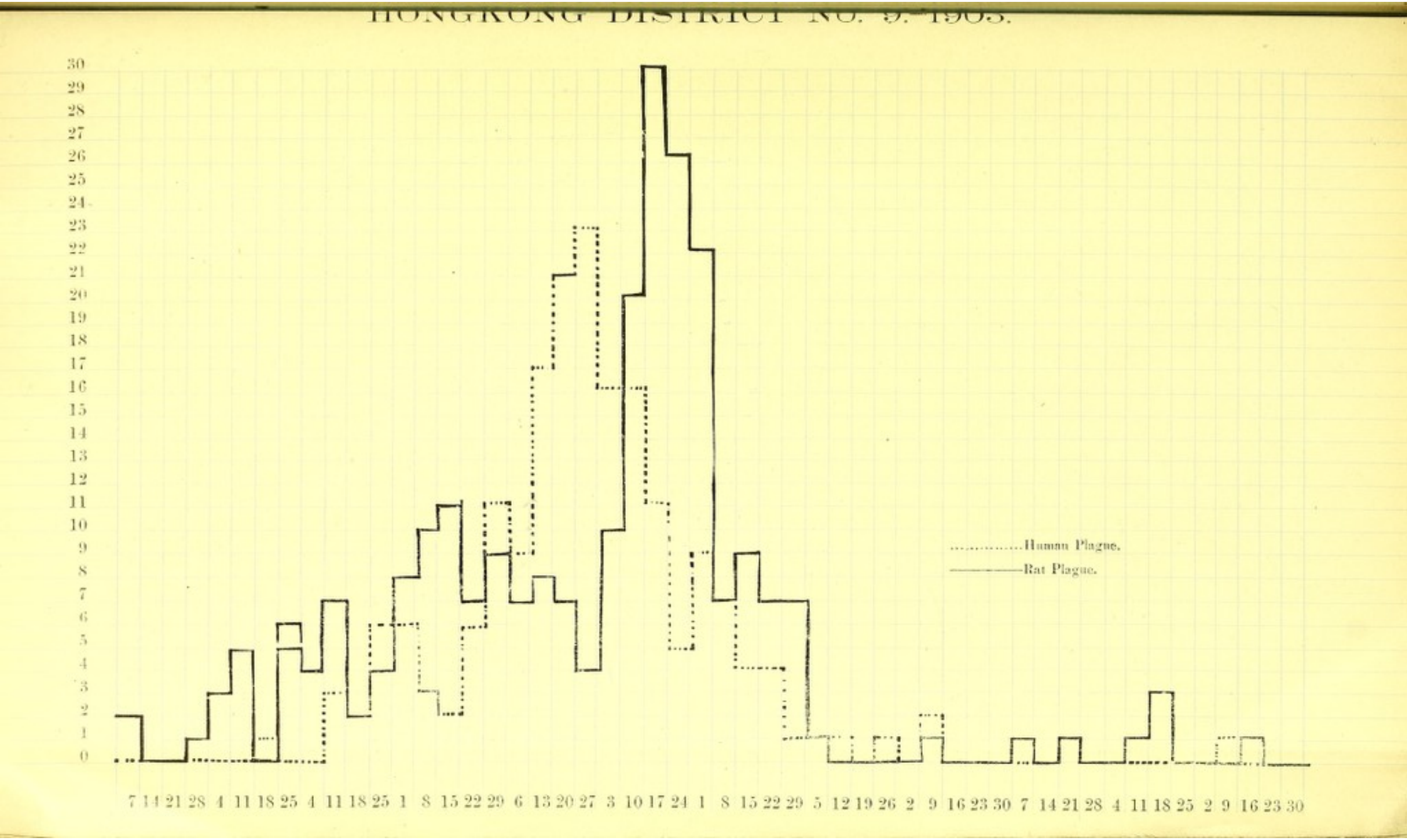


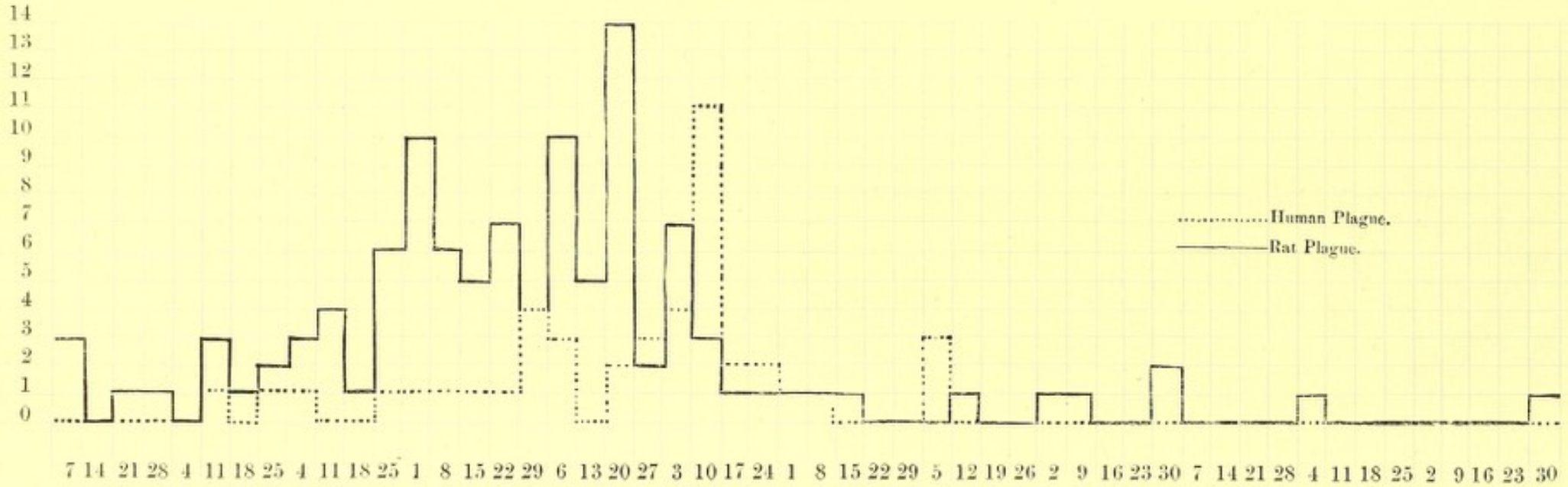
HONGKONG DISTRICT No. 8—1903



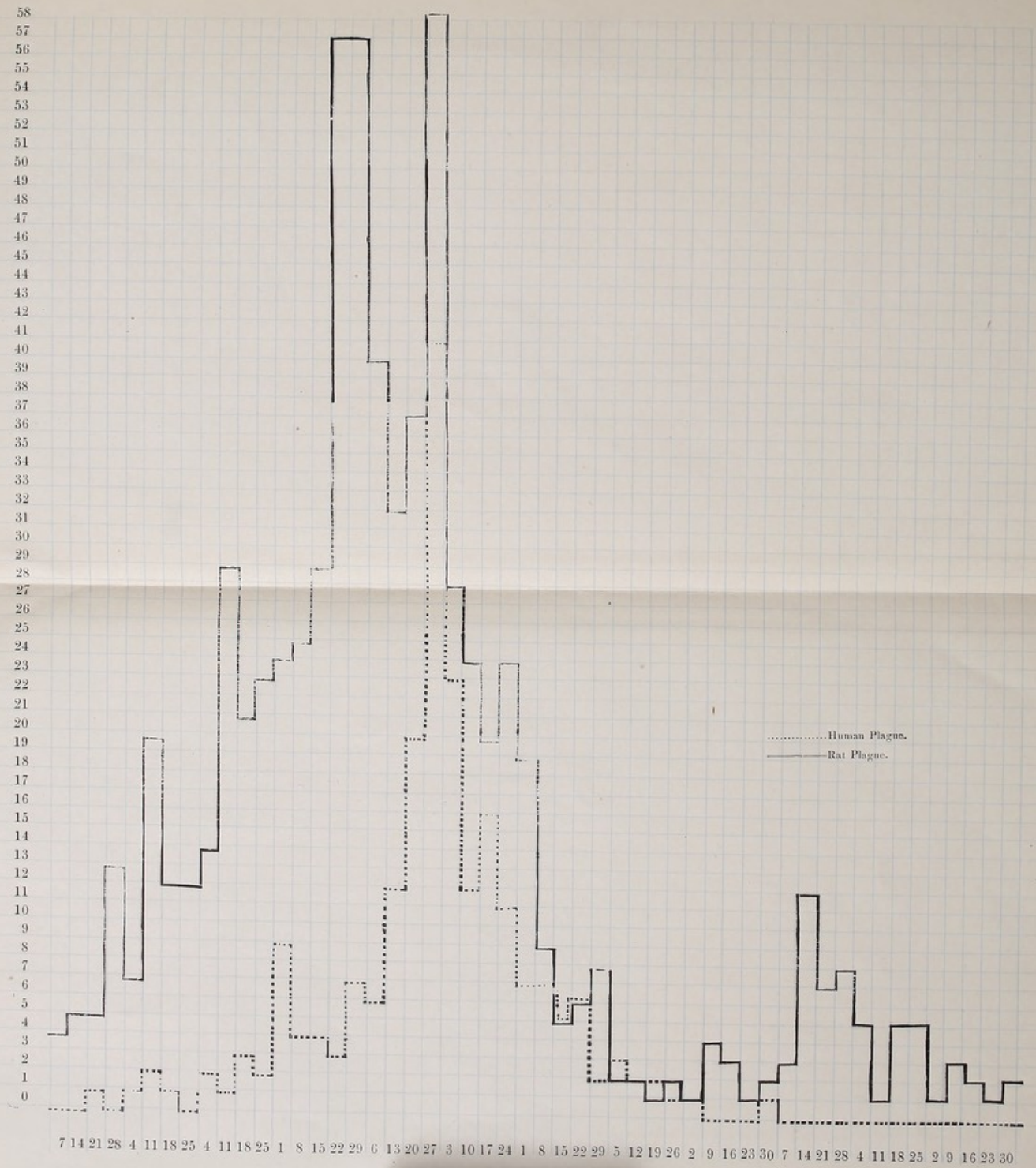
HONGKONG DISTRICT No. 5. 1903.



HONGKONG DISTRICT No. 10.—1903.



HONGKONG-KOWLOON–1903.



Thus we see that apart from the season of the year, epidemic plague appears to be preceded by epizootic plague, and that the interval of time between the outbreaks varies from ten days to a fortnight.

WILLIAM HUNTER.

The History of Health District No. 1 in 1903.—A close examination of the curves shown upon the chart prepared from this district will show how closely the two curves follow each other. Rat plague was existent at the commencement of the year. It rose in February. During January and February there was no human plague. In March, however, this appeared.

The general history of the curves is so simply given in the chart that further explanation is considered unnecessary. Note should be made of the disappearance of rat plague for practically the whole of the second half of the year.

The History of Health District No. 2 in 1903.—In my opinion this is an excellent chart for purposes of demonstrating the relation between human and rat plague.

The gradual rise in the epizootic followed closely by a gradual increase of cases of human plague. The primary decline in the epizootic followed by a lowering of the epizootic. The disappearance of rat plague followed by a disappearance of human plague.

Noteworthy is the complete immunity of the district during the last two months of the year.

The History of the Course and Relations of Epizootic and Epidemic Plague during the Initial Stages of the Outbreak of 1904.

The unexpected delay in the preparation of this report has enabled me to follow out the initial outbreaks of epizootic and epidemic plague for the year 1904.

No special charts have been prepared, but a good idea of the condition of affairs may be ascertained by consulting the chart dealing with the interval bridging over the epidemics of 1903 and 1904.

During the first week in January it will be seen that rat plague was present to a considerable extent in the Colony. The epizootic rose step by step until the beginning of February, when a rather erratic jump upwards took place. This sudden increase in the amount of rat plague was followed by the appearance of human plague a week later.

The exacerbation in the epizootic lasts only a fortnight. The number of cases per week fell considerably but did not reach the level of the epizootic previous to the sudden increase. The curve occupied now a higher level on the chart and remained more or less constant for about two months. During this period, human plague put in an appearance from time to time.

The definite increase in the number of cases of rat plague commenced about the beginning of April, and this was followed by the appearance of human plague in epidemic form.

On following the curve of the epizootic, through the month of January and the first half of February, ominous signs are present. Cases of human plague appear and the condition of affairs resembles that found at the beginning of 1903. Fortunately a decided fall in rat plague took place, and the new but more elevated position of the epizootic maintained itself weekly without further exacerbations for about 8 to 10 weeks. Human plague practically disappeared, and did not assert itself again until the epizootic broke out afresh and in continued exacerbation. Looking generally at the epizootic curve, one can see a general tendency to increase. If we compare it with that of 1903, we find a great postponement in the increase of rat plague and the occurrence of the epidemic.

WILLIAM HUNTER.

The Course and Relation of Epizootic and Epidemic Plague during the Intervals 1902, 1903, 1904.

In almost all plague infected countries, the epidemic is found to be most prevalent during certain seasons of the year. In Hongkong, our epidemics range from March to July, the month of May or even that of June, supplying the largest percentage of cases. In other countries, plague appears during the colder seasons of the year, and *vice versa*.

The reasons for such a seasonal recurrence of plague are by no means obvious. A consultation of plague literature helps one but little.

The layman's notion that climate has to do with the recurrence of plague or infectious disease in general must be pigeon-holed along with many other superstitions belonging to the pre-epidemiological days.

All that can be said of climate, is that *it may exercise an indirect influence* on the course of infection.

Under the present heading, it is not intended to discuss the factors which possibly assist in bridging over epidemics of plague. These will require consideration under a special heading. All that is intended to show at present is *the persistence of rat plague from one year to another*.

During the interval between the end of one epidemic and first cases of the succeeding epidemic, human plague is to all intents and purposes non-existent. A few cases occur, but these are of no practical importance apart from the fact that they help us to remember that with the decline of the last epidemic, our Sanatarians have in all probability not yet succeeded in stamping out the disease.

Further, the reasons for the outbreak of erratic cases of human plague, are by no means obivous.

Little or nothing is known in regard to the history of epizootic plague in rats through a number of years.

Many authorities believe that rat plague dies out on the decline of human plague.

The preparation of charts showing the relations existing between epizootic and epidemic plague during the periods July, 1902, to June, 1903, inclusive, and July, 1903, to May, 1904, inclusive, is found to show us clearly the condition of affairs which one obtains in an endemic plague centre like Hongkong.

In both charts the epidemic vanishes. Isolated cases occur periodically but are of no practical importance.

With a fall in epidemic plague, a decline in the epizootic is also observed. The latter falls to nearly the same figure as human plague.

Almost immediately afterwards, however, within a week or a fortnight the rat plague exacerbates and again reaches a high level This level means a goodly number of cases of rat plague per week, but nothing in comparison to the numbers found during the proper plague season.

The epizootic curve shows a considerable oxillation but is more regular in its course than during epidemic periods. Little change takes place in regard to the curve, until suddenly during the early part of the following year, the curve shoots upwards. Immediately this occurs, plague breaks out severely in man and becomes epidemic.

From these curves one would rightly conclude that *rat plague is epizootic continuously*.

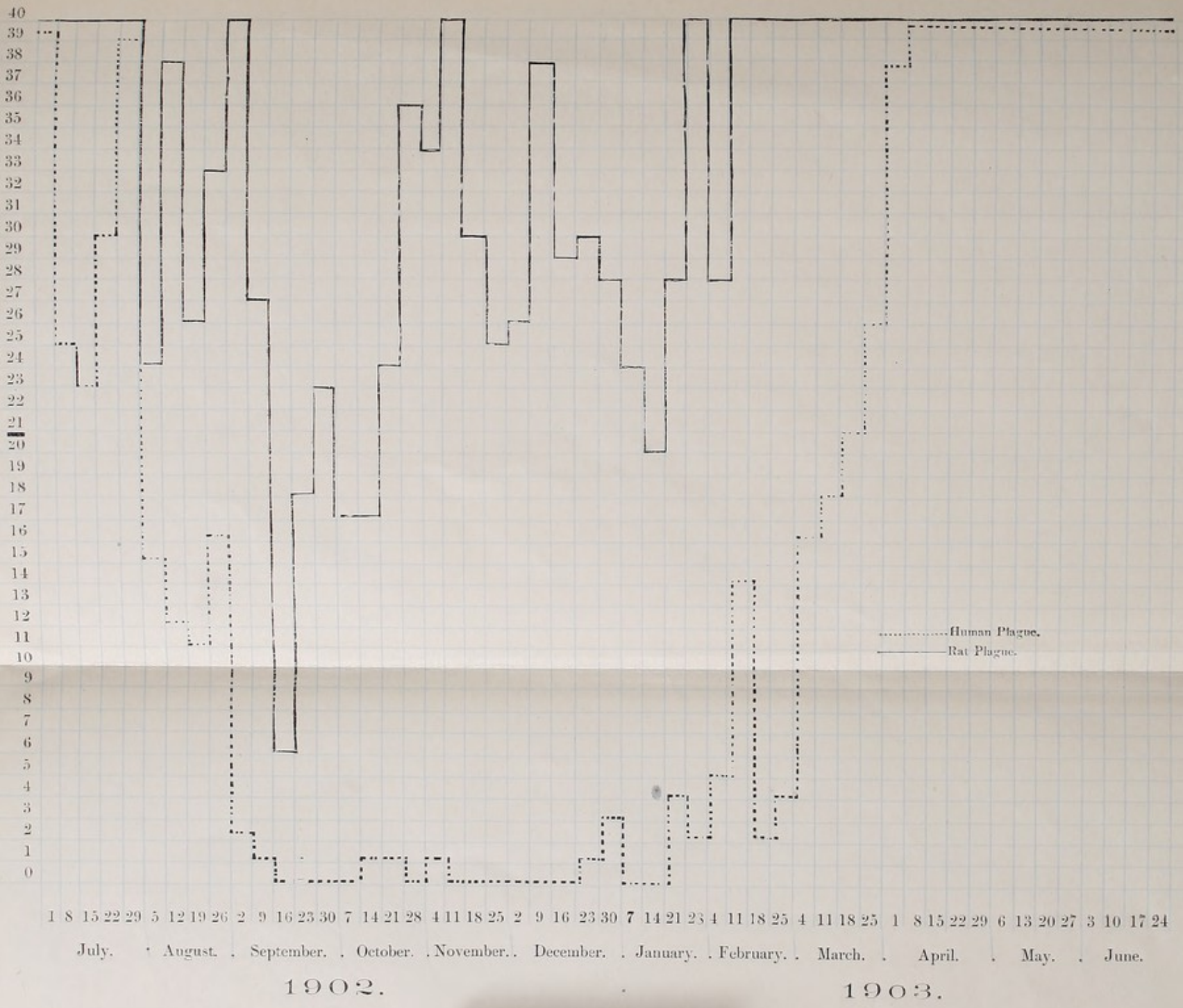
Human plague is epidemic only during the acute exacerbations of the epizootic.

Another point of importance in regard to these two charts is the following :—

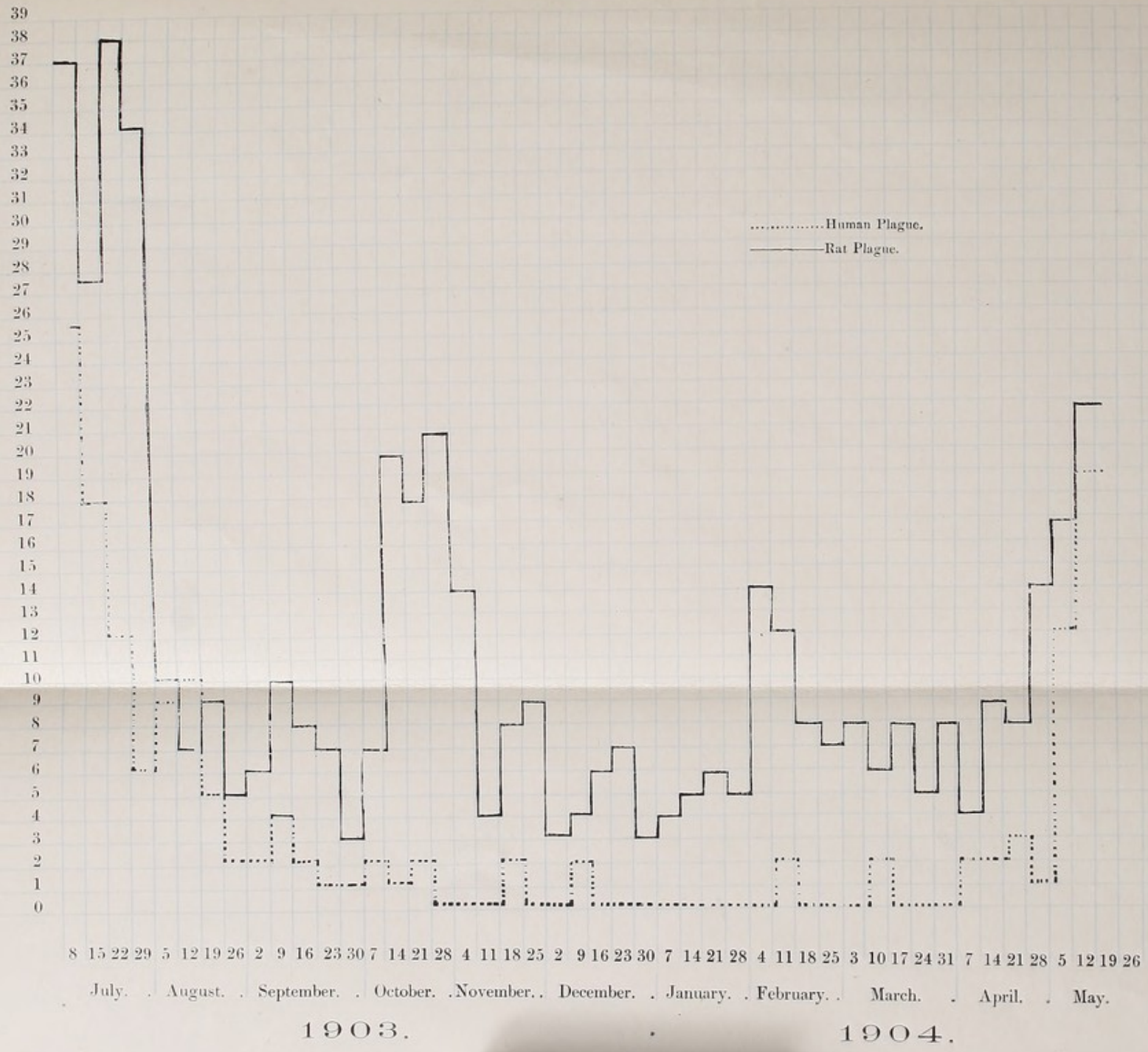
A comparison of the epizootic of 1902-03 with that of 1903-04, shows us that the former was much more severe.

The amount of rat plague at the end of 1902 was in excess. A general survey of the curve even shows its tendency to rise gradually after its sudden fall in September of 1902.

HONGKONG.—1902-03.



HONGKONG.—1903-04.



We must remember also that the epidemic of 1903 was a severe one; that of 1904 looks like a very mild one.

These charts would appear to show that *a malignant epizootic towards the end of an epidemic, means an early recurrence of human plague and a severe epidemic. On the other hand a mild epizootic would appear to indicate a late recurrence of human plague and a mild epidemic.*

Again these charts show that after a mild epidemic, the epizootic persists in amount or even gradually increases. *Vide* 1902.

After a severe epidemic, however, the epizootic persists but is present in very much less numbers and does not show the same tendency to sudden frequent and even increasing exacerbations. The reasons for such are not clear. They will be discussed under a separate heading. The condition of affairs may be stated as follows:—

1902.—Epidemic mild.
1902-1903.—Epizootic severe.
1903.—Epidemic severe.
1903-1904.—Epizootic mild.
1904.—Epidemic mild.

} The epizootic is continuous.

WILLIAM HUNTER.

Plague in Cats.

The writings of past ages tell us that during plague epidemics, domestic pets were not spared the disease. Cats, dogs and birds were known to fall a prey to the malady.

It is only within recent years, however, that the occurrence of plague in animals such as cats, which are intimately associated with man, has attracted attention. In fact until the question of rat plague was raised, the presence of plague in animals was practically lost sight of, and regarded of no practical significance in regard to the spread of the disease. With the knowledge of the presence of widespread rat plague and the fact that cats frequently devour these animals, the possible role played by cats in the dissemination of plague amongst human beings would appear to be of considerable importance. Few accounts of natural plague infection in cats are to hand. The various Plague Commissions make mere mention of cat plague, regard these animals as only slightly susceptible to the disease, and in consequence conclude that so far as the spread of plague is concerned, these animals are of no great importance.

Such an answer to the question of plague in cats is only partly true. Cats, when compared with many other animals, do appear relatively insusceptible but their importance in plague dissemination is decidedly under-rated when the subject is viewed in the light of recent experience.

In Sydney, Ashburton Thompson reports the presence of plague infection in cats, and discusses the dangers attached to such a focus of infection.

In Hongkong, we have good reason to suspect considerable plague infection amongst certain cats. The experience gained during the Plague Epidemic of 1902, and casually mentioned by me in my Annual Report for the same year, teaches us that under natural conditions, cats may become severely plague infected, and should opportunity present itself, there is no reason to doubt the spread of the infection to man by means of these animals.

We are quite prepared to admit that the disease is rare in cats, yet the possibility of the occurrence of the disease must not be forgotten.

Domestic pets may occasion broadcast dissemination of plague bacilli in the immediate surroundings of man. Experimentally produced plague in cats would appear to give inconstant results. The disease can be induced, but much depends upon the method of incorporation of the virus.

The German Plague Commission reported upon the effects of cutaneous and subcutaneous inoculation of these animals. Beyond a slight febrile reaction nothing definite was obtained. All the cats experimented upon recovered. They concluded that cats were relatively insusceptible to plague.

The results of ALBRECHT and GHON were more encouraging. They fed cats on plague infected material. Several of the animals died as the result of plague infection. The type of the disease reproduced was septicæmic. A bubo was frequently found present in the sub-maxillary region.

KOLLE also had positive results. He fed cats with cultures of plague.

WILM noted in his Report that two cats eat pieces of a plague bubo. They became ill for several days. Great emaciation of the animals was noted. The animals recovered.

From the researches on plague infection in cats, it is evident that infection per os gives the most constant results. By this method, cats would appear to contract the disease. The question of a lethal termination probably depends upon the virulence of the infecting material used for purposes of inducing the infection. During the past two years, I have had the opportunity of examining from time to time a number of cats, dead or alive, for the presence of plague infections.

In my Report for 1902, a note was made in regard to a spontaneous infection of the cats belonging to one of the Godown Companies in Kowloon.

The history of the epizootic is the following:—During the systematic collection of rats, dead and alive, in Kowloon, for bacteriological examination many of those caught in the godowns were found plague infected. A week or two after rat plague had been found, the servants of the Godown Company reported the death of several of their cats which were kept on the rat infected premises. Suspicious as to the course of death of these cats being plague, orders were given to have them examined at the Public Mortuary.

The diagnosis of plague was established immediately on bacteriological examination.

The cat mortality continued and even increased. All cats, sicks or dead, were forwarded to me. The sick cats were kept under observation in isolation.

One or two experiments were made in regard to the modes of infection in cats, and the symptoms of the disease noted as carefully as possible.

My investigations showed that plague may be either acute or chronic in cats.

Cutaneous and subcutaneous inoculation do not give constant results.

Feeding cats with plague infected material gives certain results.

The cats from the Godown Company obviously contracted the plague infection per os. The plague infection of the rats in the godowns was severe, and the cats had most probably fed sumptuously on infected rat flesh.

The Symptoms of Acute Cat Plague.—Symptoms of plague are usually present within twenty-four hours. Food is refused. Diarrhœa and vomiting are amongst the earliest symptoms. Their hair becomes raffled. Weight is rapidly lost, and emaciation is a marked feature. The abdomen is distended and tender to touch. Great weakness or even paralysis of the extremities is present. Death takes place in from 2 to 6 days.

An interesting observation is that healthy rats fed on paddy soaked in the fæces or urine of plague infected cats, die of acute rat plague.

The Post-mortem Appearance of Cat Plague.—All the tissues and organs are in a condition of extreme congestion. Hæmorrhages of varying size are scattered irregularly throughout the tissues of the animal. The lymphatic glands are congested with the presence of cortical hæmorrhages. Bubonic swellings are frequently found, especially about the neck and the mesentery.

The most interesting condition is found in the abdomen. The peritoneum is smooth and shiny. Very little fluid is found in the peritoneal cavity. The stomach is congested particulary on its mucous surface. The latter also shows the presence of innumerable hæmorrhages of varying size. No actual ante-mortem ulceration was found. The small intestine was in general reddened. Little of engrossing interest was found until the ileum was reached. This part of the gut was the seat of many small petechiæ scattered throughout its entire length. These were well seen shining through the wall of the gaseous distended gut. The mucous surface of the ileum was reddened and thickened. The latter was chiefly due to œdema. The solitary follicles were visible, being pin head in size and greyish yellow in colour. Small areas of necrosis were present, these appeared chiefly about the regions of hæmorrhagic extravasation. In one or two cases a distinct bubonic formation was found in the mesentery.

Plague bacilli were found scattered throughout the body. They were specially abundant in the lymphatic apparatus and in all bubonic areas. The fæces and the urine also contained plague bacilli. These results are similar to those obtained by KOLLE and are of great interest when compared with the type of the disease found in man.

The type of disease was in all instances septicæmic but special tendency was shown on the part of the plague bacilli to collect in the lymphatic apparatus.

Chronic Cat Plague.—This is evidenced mainly by great emaciation. Buboes are found in various situations of the body especially about the neck. These are extremely chronic in growth, accompanied by extreme surrounding infiltration and slowly break down with the production of thick creamy pus. The animals may live for two weeks to a month. The condition of those cats suffering from chronic plague is well described by the term "*Pest Marasmus.*"

The conclusions which appear to be justified from the various observations and experiments on plague infected cats are these:—

1. Cats suffer from plague.
2. The disease may be acute or chronic.
3. The type of the disease is septicæmic.
4. Plague cats scatter plague bacilli broadcast in their fæces and urine.
5. These animals must be reckoned with as occasionally playing a part in the dissemination of plague.
6. In plague infected districts, possible plague infection in cats is of great importance from a domestic point of view.
7. In plague infected areas, cats probably become infected through plague rats and mice which they devour as food.

WILLIAM HUNTER.

Plague in Mice.

When one considers how intimately associated rats and mice are in nature it is rather surprising to find so little data in regard to the possible dissemination of plague through the occurrence of Mouse Plague.

Experimentally one finds the mouse susceptible to plague. In fact its degree of susceptibility to the disease does not fall far short of that of the rat. Much of the positive evidence of experimental infection of the mouse, points to the facility with which the animal can be infected per os. Records of widespread mouse plague, in endemic plague areas are few. Indian records barely mention naturally occuring mouse infection.

In Formosa, in 1896, it is said that widespread mouse plague existed, and that these animals probably played a greater part than the rat in the dissemination of plague, which was severely epidemic during this year.

In the same year, WILM noted an increased mortality amongst mice in Hongkong. In Sydney, ASHBURTON THOMPSON noted the presence of mouse plague.

In Alexandria, GOTSCHLICH found epidemic plague existent in areas more or less severely affected with the mouse epizootic.

My own experience leads me to believe, that during plague epidemics in Hongkong, mouse plague is prevalent. Hundreds of mice have been examined bacteriologically and many found plague infected. My own researches up to the present time, however, do not warrant any definite conclusion in regard to the significance of the epizootic. My examinations have been only occasional. In the absence of a systematic investigation, one cannot definitely express an opinion as to the part played by these vermin in the furtherance of the disease. It would appear highly probable, however, that in many instances, mice play as important a part as rats, and that in dealing with epizootic plague, our sanitary efforts must be directed to mice as well as rats.

WILLIAM HUNTER.

The Susceptibility of Aminals in general to Plague Infection.

It would be out of the scope of a research like the present, to enter more or less fully into the question of the susceptibility of animals in general to plague.

In regard to many animals I have nothing to add to what is already generally known. The experiments carried out by Professor SIMPSON and myself, would appear to shed much light on this hitherto much discussed question. A report has already appeared in regard to these experiments.

The Guinea Pig.—This animal shows practically the same degree of susceptibility to plague as the rat. It contracts the disease by all the well recognised methods of natural and artificial induction. Acute and chronic plague are common. Frequently a condition of *Pest Marasmus* is found in chronically infected animals.

It is the most suitable animal for experimental inoculation, and the isolation of the B. pestis from complicated micro-organismal mixtures. By cultural methods, the isolation of plague bacilli from the fæces, decomposing corpses or fluids, is practically an impossibility. In cultures the B. pestis is rapidly overgrown by ordinary non-pathogenic saprophytes.

It is known that saprophytic bacteria and ordinary intestinal micro-organisms, produce practically no pathological changes when rubbed into the shaved skin of a rat or a Guinea pig.

I have obtained excellent results with healthy rats. These results are in perfect accord with the observations of FRITSCHE (Arb. Kais. Ges—Amt. Bd. 18, 1902) and MARTINI (Zeit. f. Hyg. Bd. 41, 1902).

The bacteria which may be present in such mixtures of micro-organisms scarcely ever produce after careful cutaneous inoculation the characteristic pathological changes of plague infection, namely, the extensive haemorrhagic infiltration of the connective tissue, the bubonic swellings and the focal necroses in the spleen.

An interesting pathological appearance is occasionally found, when plague bacilli of extremely low virulence are injected into the peritoneal cavities of Guinea pigs. Chronic plague is produced, and tumour like growths develop on the surface of the peritoneum, the liver, spleen and other organs. These are of the nature of granulomata, and resemble tubercular or actinomycotic lesions. I have found a condition similar in the rat when suffering from chronic plague. Small nodules of soft granulomatous tissue were found in the peritoneal cavity, in the liver, and the spleen. Plague bacilli were present, but difficult of direct microscopic demonstration.

Plague in Rabbits.—These animals are much more resistant than either the rat or the Guniea pig. The type of disease produced is septicæmia. This would not appear to depend upon the mode of incorporation of the virus.

Plague in Pigs, ...
Calves, ...
Sheep,.....
Monkeys, ...
Hens, ...
Pigeons, ...
Turkeys,.....
Geese,.....
Ducks, ...

} Simpson and Hunter's experiments. *Vide* Simpson's Report on Plague in Hongkong.

So far as *Monkeys* are concerned, the Semnopithecus entellus would appear to be much more susceptible to plague infection to the Macacus rœsus. (Russian Plague Commission.)

Squirrels are also susceptible to plague. (German Plague Commission.)

Dogs are relatively insusceptible to plague. Albrecht and Ghon found that these animals discharged numerous plague bacilli in their fœces, after eating grossly infected plague material.

Goats may also contract plague. *Snakes*, *Lizards* and *Frogs* may suffer from plague but only under certain conditions.

Their body temperature would appear to affect, unfavourably, the growth of the B. pestis. Nuttall (Cent. f. Bakt. Bl. 22, 1897) found that *vipers* and *lizards* were insusceptible to plague at a temperature of 16° to 18° C. On raising the temperature to 26° or 28° C. these animals readily contrated the disease.

General Conclusions in regard to the Occurrence of Epizootic Plague.—

1. Plague infected human beings may infect animals, and *vice versa*.
2. Plague infected animals may infect other healthy animals.
3. Domestic animals suffering from plague may infect man.
4. Epizootic plague occurs in acute and chronic forms.
5. Latent plague may also occur.
6. Rats and Guinea pigs would appear to be most susceptible to plague.
7. The mouse comes next in order of susceptibility.
8. Monkeys, especially the grey monkey, are extremely susceptible to plague.
9. Cats may contract the disease naturally.
10. Birds may also suffer from the disease in nature.
11. Practically every vertebrate animal found in the immediate neighbourhood of man, may be rendered plague infected.
12. The induction of the disease by feeding gives the most constant results.
13. The type of disease reproduced in animals is a true septicæmia.
14. Animals suffering from plague scatter plague bacilli broadcast in their secretions and excretions.

Spontaneous Epizootic Plague.—Direct obervation of this has been noted for the following animals :—

1. The Rat.
2. The Mouse.
3. The Cat.
4. The Guinea Pig.
5. The Monkey.
6. The Hen.
7. The Pigeon.
8. The Turkey.
9. The Goose.
10. The Duck.
11. The Marmot (Arctomys bobac).

WILLIAM HUNTER.

1902. DISTRICTS.

R.=Rat Plague.
H.=Human Plague.

DATE.		Kowloon.		No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		No. 7.		No. 8.		No. 9.		No. 10.		Total.		REMARKS.
		R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	Rat.	Human.	
April, ...	8	5	1	2	...	7	...	...	1	2	...	...	...	3	...	1	...	2	...	4	...	...	...	26	2	
	15	20	...	2	...	9	...	...	1	...	1	...	...	...	...	...	...	...	...	2	1	...	...	33	3	
	22	18	1	6	...	7	1	2	1	2	1	1	...	2	...	1	...	...	...	8	...	1	1	48	5	
	29	26	...	3	...	6	...	1	...	7	...	...	...	2	2	3	2	2	...	4	2	7	...	61	6	
May, ...	6	31	1	1	1	10	1	2	2	17	6	4	4	5	2	6	...	18	1	7	7	10	5	111	30	
	13	38	4	3	2	15	5	4	...	16	3	9	1	10	1	13	2	16	2	12	2	8	1	144	23	
	20	45	5	4	1	10	2	2	1	15	2	13	3	3	1	18	1	17	3	11	5	3	3	141	27	
	27	35	4	2	...	5	1	1	3	24	1	7	3	3	2	13	1	13	3	14	8	7	10	124	36	
June, ...	3	29	13	1	2	...	4	1	...	11	5	3	3	1	5	6	3	10	...	10	9	3	9	75	53	
	10	27	9	1	3	...	3	2	2	17	...	3	2	2	1	5	1	14	3	11	10	5	7	87	41	
	17	32	3	1	1	2	2	1	1	8	1	3	6	1	1	6	2	11	3	8	12	1	6	74	38	
	24	25	7	...	2	3	3	7	2	3	1	5	9	1	..	3	...	15	...	6	10	1	1	69	35	
July, ...	1	18	2	2	3	5	4	...	2	8	2	2	...	2	8	2	...	8	3	5	12	2	1	54	37	
	8	14	2	6	1	7	3	2	...	16	...	6	2	7	...	8	...	10	6	6	2	2	5	84	21	
	15	18	5	6	1	2	3	4	2	16	2	4	...	6	...	7	2	8	...	5	4	2	3	78	22	
	22	15	6	3	2	1	2	...	1	16	2	10	2	5	...	8	1	8	1	9	4	4	4	79	25	
	29	16	3	1	2	3	4	2	...	15	2	4	2	5	4	7	3	11	2	11	6	1	1	76	29	
August, ...	5	4	2	...	2	2	1	1	...	4	...	2	2	...	2	5	1	4	4	1	5	1	2	24	21	
	12	6	...	...	...	1	2	2	1	3	...	5	1	1	2	6	...	10	1	3	...	1	3	38	10	

DISTRICTS,—*Continued.*

DATE.		Kowloon.		No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		No. 7.		No. 8.		No. 9.		No. 10.		Total.		REMARKS.
		R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	Rat.	Human.	
August, ...	19	1	1	2	1	3	1	2	...	7	3	1	...	3	...	3	1	3	1	1	2	...	...	26	10	
	26	2	...	4	...	2	2	1	...	4	1	...	1	4	2	5	1	10	1	...	3	1	3	33	14	
September, ...	2	5	1	7	1	...	...	3	...	8	...	...	...	3	...	4	...	7	...	4	...	1	...	42	2	
	9	10	...	...	1	2	...	...	...	4	...	6	...	...	...	1	...	2	...	1	...	1	...	27	1	
	16	2	...	2	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	6	...	
	23	4	...	...	...	1	...	...	...	4	...	2	...	1	...	1	...	...	...	2	...	...	...	15	...	
	30	10	...	...	...	4	...	...	...	3	...	1	...	2	...	1	...	...	...	...	...	1	...	22	...	
October, ...	7	6	...	2	...	1	...	...	...	3	...	2	...	3	...	...	...	...	...	...	...	...	...	17	...	
	14	3	...	1	...	1	...	2	...	1	...	3	...	2	...	1	...	2	...	...	1	1	...	17	1	
	21	7	...	1	...	...	...	...	...	7	...	2	1	1	...	1	...	4	...	...	...	...	...	23	1	
	28	15	...	...	...	2	...	1	...	2	...	3	...	8	...	3	...	2	...	...	...	...	...	36	...	
November, ...	4	9	...	...	...	1	...	...	...	10	...	1	...	5	...	2	...	6	1	...	...	...	...	34	1	
	11	17	...	...	...	5	...	...	...	14	...	5	...	7	...	...	...	9	...	...	...	...	...	57	...	
	18	15	...	...	...	...	...	...	...	1	...	3	...	6	...	1	...	3	...	1	...	...	...	30	...	
	25	10	...	...	...	1	...	1	...	3	...	...	...	4	...	3	...	2	...	1	...	...	...	25	...	
December, ...	2	16	...	2	...	...	...	...	...	1	...	1	...	1	...	1	...	2	...	2	...	...	...	26	...	
	9	17	...	1	...	...	...	...	...	2	...	6	...	1	...	7	...	3	...	...	...	1	...	38	...	
	16	14	...	2	...	...	...	...	...	2	...	2	...	3	...	2	...	4	...	...	...	...	...	29	...	
	23	11	...	...	...	9	...	...	...	1	1	...	...	1	...	1	...	3	...	1	...	1	...	28	1	
	30	10	...	3	...	6	...	1	...	2	2	...	...	5	1	...	...	2	...	...	...	...	...	29	3	

1903.

DISTRICTS.—*Continued.*

DATE.		Kowloon.		No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		No. 7.		No. 8.		No. 9.		No. 10.		Total.		REMARKS.
		R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	Rat.	Human.	
January, ...	7	4	...	3	...	5	...	...	...	2	...	...	...	...	...	1	...	3	...	2	...	3	...	23	...	
	14	5	...	...	...	3	...	1	...	2	...	1	...	4	...	...	...	1	...	...	...	...	...	17	...	
	21	5	1	3	...	7	1	1	...	6	...	2	...	...	...	2	1	...	...	...	...	1	...	27	3	
	28	13	...	2	...	11	1	...	...	6	...	1	...	3	...	2	...	3	...	1	...	1	...	45	1	
February, ...	4	7	1	1	...	5	1	...	...	5	1	...	...	1	...	2	...	3	...	3	...	...	...	27	3	
	11	20	2	4	...	12	2	1	...	11	...	1	1	5	1	6	4	12	1	5	...	3	1	80	9	
	18	12	1	3	...	12	...	1	...	12	..	4	...	1	1	2	...	7	...	...	1	1	...	54	3	
	25	12	...	4	...	8	1	...	1	13	1	5	...	3	1	5	...	13	1	6	...	2	1	71	6	
March, ...	4	14	2	9	2	10	5	2	...	16	2	10	...	4	2	12	...	26	...	4	...	3	1	110	14	
	11	29	1	9	2	7	6	...	1	11	...	9	1	2	2	8	1	14	1	7	3	4	...	110	18	
	18	21	3	13	1	25	6	1	...	15	4	10	...	7	2	10	...	19	...	2	2	1	...	124	18	
	25	23	2	3	4	31	5	5	1	18	1	17	1	13	3	12	4	21	3	4	6	6	1	153	31	
April, ...	1	24	9	5	5	40	4	6	...	18	6	10	3	12	3	22	3	29	1	8	6	10	1	184	41	
	8	25	4	9	3	10	16	1	1	15	10	18	1	15	2	24	2	21	1	10	3	6	1	154	44	
	15	29	4	7	5	9	8	...	1	14	5	15	3	16	5	18	1	11	1	11	2	5	1	135	36	
	22	57	3	11	10	22	20	2	...	8	9	15	10	16	5	14	1	14	4	7	6	7	1	173	69	
	29	57	7	12	8	5	20	3	2	12	12	15	9	14	7	13	2	12	...	9	11	4	8	156	86	
May, ...	6	40	6	12	6	8	20	1	...	16	8	26	12	33	8	12	7	31	4	7	9	10	3	196	83	
	13	32	12	9	1	5	19	5	3	20	9	24	8	45	7	42	5	48	10	8	17	5	...	243	91	

DATE.		Kowloon.		No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		No. 7.		No. 8.		No. 9.		No. 10.		Total.		REMARKS.
		R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	Rat.	Human.	
May, ...	20	37	20	8	1	6	16	4	3	15	14	24	8	51	3	22	12	33	7	7	20	14	2	221	106	
	27	58	41	1	6	9	20	4	2	19	11	20	8	40	5	33	8	28	6	4	22	2	3	218	132	
June, ...	3	28	23	5	7	4	10	...	1	14	19	25	7	35	7	31	7	25	6	10	16	7	4	184	107	
	10	24	12	8	4	6	13	1	2	13	10	15	9	24	4	16	8	36	10	20	16	3	11	166	99	
	17	20	16	3	1	5	2	3	...	14	2	17	2	20	3	22	3	38	4	30	11	1	2	173	46	
	24	24	11	4	1	3	4	3	...	13	2	21	1	21	2	23	2	29	3	26	5	1	2	168	33	
July, ...	1	19	7	3	...	4	1	5	...	7	...	13	1	20	2	3	...	10	1	22	9	1	1	107	22	
	8	9	7	1	1	1	2	6	2	1	...	5	1	7	4	...	1	...	...	7	7	1	1	39	26	
	15	5	5	...	...	...	2	...	...	6	2	1	2	...	...	2	1	2	1	9	4	1	...	26	17	
	22	6	6	...	...	2	2	...	...	2	...	4	...	10	...	3	...	3	...	7	4	...	...	37	12	
	29	8	2	...	...	...	1	...	1	2	...	3	...	6	1	5	...	2	...	7	1	...	...	33	6	
August, ...	5	2	3	...	...	...	1	...	...	...	1	2	1	1	...	2	...	2	...	1	1	...	3	10	9	
	12	2	2	...	2	...	...	...	1	1	1	...	...	1	2	...	...	...	1	...	1	1	...	5	10	
	19	1	2	1	1	2	1	1	...	1	...	1	1	1	1	3	...	1	...	...	...	...	...	12	6	
	26	2	1	...	...	...	...	1	...	...	...	...	...	1	...	1	...	...	...	...	1	...	...	5	2	
September, ...	2	1	1	1	...	...	...	1	...	...	...	...	...	1	...	1	...	...	...	...	...	1	...	6	1	
	9	4	...	...	...	...	...	...	1	...	1	1	...	...	...	2	...	...	...	1	2	1	...	9	4	
	16	3	...	1	...	1	1	...	1	...	...	1	...	...	...	1	...	...	...	...	...	...	...	7	2	
	23	1	...	...	...	1	...	2	1	...	...	...	...	...	...	1	...	...	...	...	...	...	...	5	1	
	30	2	1	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	2	...	4	2	

DISTRICTS,—*Continued.*

DATE.		Kowloon.		No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		No. 7.		No. 8.		No. 9.		No. 10.		Total.		REMARKS.
		R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	Rat.	Human.	
October, ...	7	3	...	...	2	...	...	1	...	1	...	...	...	...	...	1	...	2	...	1	...	...	...	7	2	
	14	12	...	...	...	1	1	...	...	2	...	...	...	2	...	1	...	1	...	...	...	...	...	19	1	
	21	7	...	...	...	...	1	...	1	2	...	2	...	1	...	3	...	2	...	1	...	...	...	18	2	
	28	8	...	1	...	...	...	...	...	...	...	1	...	1	...	1	...	1	...	...	...	...	...	13	...	
November, ...	4	5	...	...	...	...	...	...	...	1	...	...	...	3	...	2	...	1	...	...	...	1	...	13	...	
	11	1	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	1	...	...	...	4	1	
	18	5	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	3	...	...	...	8	2	
	25	5	...	...	...	...	...	...	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...	8	...	
December, ...	2	1	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	3	...	
	9	3	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	2	...	...	4	2	
	16	2	...	...	...	...	...	...	...	...	...	...	...	1	...	2	...	...	...	1	...	...	...	6	...	
	23	1	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	3	...	
	30	2	...	...	...	...	...	1	...	...	...	...	...	...	...	1	...	...	...	...	...	1	...	5	...	
1904.																										
January, ...	7	2	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	1	...	...	...	...	...	4	...	
	14	3	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	5	...	
	21	4	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	5	...	
	28	2	...	...	...	...	...	1	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	5	...	
February, ...	4	3	...	...	...	2	...	1	...	...	...	...	...	1	...	3	...	3	...	1	...	...	...	14	...	
	11	4	...	...	...	...	...	1	...	...	...	...	...	2	...	3	...	1	...	1	1	...	...	12	2	

DISTRICTS.—*Continued.*

DATE.		Kowloon.		No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		No. 7.		No. 8.		No. 9.		No. 10.		Total.		REMARKS.
		R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	R.	H.	Rat.	Human.	
February, ...	18	3	...	...	...	1	...	...	...	...	...	1	...	...	...	2	...	1	...	...	...	...	...	8	...	
	25	1	...	1	...	1	...	1	...	...	...	...	...	...	...	...	...	2	...	...	...	1	...	7	...	
March, ...	3	3	...	...	...	1	...	...	...	2	...	...	...	...	...	1	...	...	...	1	...	...	...	8	...	
	10	3	1	...	...	...	...	...	...	...	...	...	...	2	...	1	1	...	...	...	...	...	...	6	2	
	17	4	...	...	...	...	...	...	...	1	...	...	...	1	...	1	...	1	...	...	...	...	...	8	...	
	24	...	...	...	...	1	...	1	...	1	...	...	...	...	...	...	...	2	...	...	...	...	...	5	...	
	31	2	2	...	...	1	...	1	...	...	...	1	...	...	...	2	...	...	...	1	...	...	...	8	2	
April, ...	7	1	1	...	...	...	...	...	...	1	...	1	...	...	...	...	...	1	...	...	1	...	...	4	2	
	14	1	2	...	...	1	...	1	...	2	...	...	...	...	...	2	...	2	...	...	...	...	1	9	3	
	21	3	1	...	...	1	...	2	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	8	1	
	28	3	3	...	...	1	...	1	...	...	...	...	...	1	2	3	...	2	1	2	6	1	...	14	12	
May, ...	5	5	6	...	...	1	2	1	...	3	...	2	...	2	...	...	...	1	3	2	7	...	1	17	19	
	12	5	3	2	...	4	2	1	3	1	...	...	2	1	...	1	1	1	2	3	...	3	...	22	13	
	19	...	6	...	2	...	1	...	...	...	...	...	...	...	...	...	...	...	2	...	5	...	5	...	21	
	26	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	