

Epidemiological Section.

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Sir SHIRLEY MURPHY, Vice-President of the Section, in the Chair.

Plague in Manchuria.

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DURING the winter of 1910-11 Manchuria was ravaged by an outbreak of pneumonic plague, which recalls some of the historic outbreaks of the Middle Ages, but to which modern times afford no parallel.

When compared with the mortality caused by bubonic plague in India, the actual proportions of the Manchurian epidemic do not seem large, but it captured the popular imagination by reason of the dramatic features which attended it, its mysterious origin, rapid spread, and appalling virulence.

I will pass lightly over the features which intensified the dramatic interest of the outbreak, before considering those facts which have a more serious interest for ourselves as epidemiologists.

The Manchurian plague outbreak has in a high degree the fascination that belongs to all that is Oriental and mysterious. The disease is believed to have been transmitted to man by the tarabagan, a large marmot inhabiting the remote wilds of Siberia and Mongolia. The first human victims claimed were probably trappers who hunt and trap this animal for the sake of its fur. After an explosive outbreak in Manchu-li, the frontier town of Siberia and Manchuria, and in Harbin, it was rapidly carried south along the railway and the roads by the hordes of Chinese coolies from Shantung, who migrate every year into Manchuria for the soya-bean harvest, and return home to worship their ancestors at the Chinese New Year. The plague travelled through Manchuria,

the Tartar province whence issued the present Manchu dynasty, the conquerors of China, by a route every mile of which has been fought over by the Russians and Japanese, to whom Manchuria is as Naboth's vineyard, along railway lines which are partly Russian, partly Japanese, and partly Chinese. In consequence, the difficulties of sanitary administration were enormously enhanced by international diplomatic complications. The virulence of the infection was such that in many instances whole families and large households were mown down by the disease, and its fatality so appalling that out of more than 40,000 cases only three recoveries are claimed. Those who took the disease passed rapidly into a stuporous condition and died generally within forty-eight hours. Men walking along the streets would be observed to stagger, reel, and fall. Where they fell, there they lay crouching, for none dared succour them. They passed from stupor into coma, and died shunned and untended. The poor corpse lay frozen stiff in the attitude of death by the bitter cold, till the burial coolies came and dragged it away with ropes and hooks. None dared give shelter to a stricken patient, and the sick were often thrust out into the streets to die, lest their death should implicate the household. Those who died were often hidden in the "k'angs" or under the roofs of their houses, or in other places of concealment.

Burial was impossible, for the temperature of Manchuria in winter is often 40° F. below zero, and the ground is frozen hard to a depth of more than 3 ft. Eventually sanction was given—for the first time in Chinese history—to cremation, and in several towns piles of bodies—coffined or uncoffined—that had been lying unburied for weeks were burned on pyres or in huge pits.

The sick were tended in hospital by mysterious figures swathed from head to foot in white robes and hoods, their eyes concealed by goggles and their features by gauze masks, like members of some awful Vehmgericht whose doom was certain death. In several instances those that tended the sick fell victims to the plague—the French Dr. Mengy, two French Sisters of Charity in Chi-fu, the Russian Marmontoff, Dr. Jackson, of Moukden—whose funeral oration, spoken by the Viceroy of Manchuria, is a monument of Chinese eloquence—and others.

The dread of plague was over all society. In stricken towns commerce and social intercourse were at a standstill. Those of stricken households were refused admission into shops or into the homes of their friends and kinsfolk, and often depended for sustenance entirely on food left by neighbours outside their doors.

The guards at the city gates, the police in the streets, the railway military guards, all wore masks, and many private citizens would not venture abroad without a mask. A gauze mask was an indispensable part of the uniform of every Japanese soldier in Manchuria for several months, and was conscientiously worn, whereas the Chinese soldiers and police were often content to wear theirs round their necks. When Dr. Petrie and I visited Schuang-cheng-fu we were preceded by a military escort of sixty cavalry with band and banner. All the escort wore masks, and even the commander of the escort carried a gauze mask, worn as a sword-knot. In Chi-fu the attempt to induce contacts and the travelling coolies in inns to wear masks was only successful when these masks were stamped in vermilion with a temple seal, and so could be regarded as amulets.

I have said enough to indicate and to explain the profound impression made by the plague in Manchuria upon the Government and upon society generally. When, however, we come to consider in cold blood the actual extent of this epidemic, we are surprised to note that its real proportions were, in fact, relatively small; we find that it was brought under control with comparative ease, despite the complete absence at the moment of its outbreak of an organized sanitary service in China; and the limitation of the epidemic rather than its extension is found to be the factor that requires explanation.

The number of plague deaths in Manchuria as ascertained by careful official computation was 43,972, and if we allow for the few cases that occurred outside Manchuria, and for deaths concealed or otherwise not ascertained, we shall be justified in assuming that the total mortality was little, if at all, in excess of 45,000.

It is impossible to estimate with any degree of accuracy the fluctuating population of Manchuria, and the official returns cannot be regarded as trustworthy, but it has been computed on good authority to be about twenty millions. In this computation thirteen millions are assigned to the Province of Feng-tien, five millions to Kirin, and two millions to Heilung-chiang. On this basis the attack-rate would be about 2.25 per 1,000 of population, and as practically all cases were fatal, the total mortality would be in the same ratio. It must, however, be remembered that the incidence of the disease was almost entirely confined to towns in the railway zone, or in its neighbourhood.

When we remember that plague has caused a total mortality of

more than seven million deaths in India, during the last fifteen years, that for three years (1904, 1905, and 1907) the total annual mortality has exceeded the million, that in some years deaths have occurred at the rate of 20,000 or 30,000 a week for months in succession, and that even during the current year more than 600,000 deaths have occurred during the first eight months, it is obvious that it is not in respect of its mere bulk that the Manchurian plague outbreak has any special importance. On the other hand, special interest does attach to the behaviour of the outbreak, and we have to ask ourselves—What was its origin, what its nature, and what were the circumstances that explain, on the one hand, its explosive outbursts, on the other, its rapid decline and complete cessation?

It is now matter of common knowledge that the tarabagan (*Arctomys bobac*), a hibernating marmot of the size of a large cat, found in Mongolia, in North-west Manchuria and in Transbaikalian Siberia, is susceptible to plague infection, and that plague epizootics occur not infrequently amongst these animals. They are said to hibernate during the winter months, say from September to March; when they emerge in the spring the younger animals seek new homes in which to breed. The new burrows, it is said, often run into old "earths," which may contain dead animals left from a previous season, by which the younger generation may be infected. The tarabagan is hunted and trapped by Buriats, Mongols and Cossacks for the sake of its fur, its flesh, which is esteemed a delicacy, and its fat, which is used for lubricating leather. This circumstance supplies probably the initial factor in the Manchurian outbreak—an animal liable to epizootic plague, and men by whom that animal is hunted. It does not, however, suffice to explain its rapid diffusion.

Dr. Clemow has collected records of small outbreaks, each comprising less than a dozen cases, which have occurred in recent times among Cossacks and Mongolians; and it is probable that there have been in the past many such localized occurrences. But these visitations affecting semi-nomadic families in sparsely populated regions have not, at any rate within the last two and a half centuries, led to any wide diffusion of the disease, and it is recorded that when they do occur the members of affected families are rigorously isolated from contact with their neighbours. Moreover, the regular trappers have learnt, probably from the experience of many generations, to recognize the signs of plague in the tarabagan. The plague-stricken animal is languid and ceases

to utter its peculiar barking cry, which the Chinese say resembles the words "Pu pa," meaning "there is no fear," and is regarded by them as an assurance that the beast may safely be caught. Its gait becomes unsteady. As a confirmatory test the hunters are wont to make an incision into the paw of the animal. If the blood is coagulated and does not flow readily the animal is regarded as diseased and given to the dogs, which are said not to suffer from eating it. Not only do the experienced hunters reject plague-stricken animals, but it is said that they quit the districts in which they are found.

If, then, the Manchurian plague may be attributed in its inception to the tarabagan, additional factors to those already given are required to account for its diffusion.

The first of these is the fact of an enormous increase in the demand of Europe and America for marmot-skins, which are not only sold as such, but are also dyed and sold as imitation sables. This increased demand has attracted inexperienced hunters—mostly Shantung coolies—to the industry, and whereas the experienced trappers hunt or trap their quarry in the open, and so catch as a rule only healthy animals, these new hands have nearly always dug the animals out of their holes, into which, if diseased, they creep to die, or have run down in the open stricken specimens too languid to escape.

Another factor, the most important of all, is the enormous annual migration from the Shantung province into Manchuria. The Province of Shantung is in the drainage area of the Yellow River which, owing to the frequent disastrous floods to which it is liable, is known as "China's Sorrow." The hardy and adventurous Shantung coolie is therefore driven to seek employment at a distance from his native home. Thousands of these coolies annually migrate to the rich Manchurian provinces, which are crying out for additional labour for the soya-bean harvest and other industries. Thousands also found lucrative and congenial employment in the Transvaal mines till they were recently excluded from South Africa by the action of the British Government. This exclusion had the effect of adding enormously to the usual invasion of Manchuria from Shantung.

Now it is a cardinal requirement of the Chinaman's religion that he shall, if it is in any way practicable, return home to worship his ancestors, collect and pay his debts, and perform other social obligations at the Chinese New Year which falls early in January. Hence it happened that thousands of Shantung coolies were travelling during the latter part of December and the beginning of January by road and rail

along the route that runs in a south-easterly direction from Manchu-li to the Liao-tung peninsula. This exodus corresponds with the track of the plague, as will be evident on reference to the accompanying map.

The disease first appeared, so far as our positive knowledge carries us, in Manchu-li (Lupin-fu), on October 25, being probably first introduced—though we have not definite evidence as to this point—by tarabagan trappers. Five hundred and twenty-two deaths occurred in Manchu-li. On November 8 plague appeared in the great railway junction town Harbin, being introduced by two tarabagan trappers from Manchu-li. Intermediate towns on this line—Hulun (twenty cases), and Lung-kiang-fu (1,402 cases), were attacked on November 9 and 13 respectively. Harbin, or rather Fu-chia-tien, the native town which adjoins it, bore the chief brunt of the plague, 5,272 deaths occurring in Harbin and Fu-chia-tien, and 1,449 on the Harbin railway line. From Harbin the plague radiated in different directions by road, breaking out at Pinchow (1,184 cases) on December 18, Hulan-fu (6,067 cases) on December 17, Suihua-fu (1,583 cases) on January 1, Hailun-fu (2,057 cases) on the same date, Pa-yem (1,123 cases) on January 23, Acheng (1,794 cases) on December 23, besides minor outbreaks. Proceeding down the railway-line, Shuang-cheng-fu (4,551 cases) was attacked on January 2, Chang-chun (3,104 cases) on January 3, Kirin-fu (623 cases) on January 18, Moukden (2,571 cases) on January 2.

The almost simultaneous outbreaks occurring at Shuang-cheng-fu, Chang-chun, and Moukden, point strongly to conveyance of the disease by rail, and correspond with the rush homeward of the Shantung coolies for the Chinese New Year. We have also positive evidence that numerous cases were found on the trains, and particularly in the crowded coolie carriages. The map (fig. 1) shows that radiation by road to surrounding villages occurred from the railway junctions of Chang-chun and Moukden.

The plague made some progress along the Chinese railway from Moukden onwards, but was practically arrested by the Great Wall at Shanhaikwan, very few cases, I believe only about a score, occurring at Peking. About ninety cases are known to have occurred in Tientsin. This arrest is due partly to the strict railway quarantine established, when once the danger was recognized at Chang-chun, Moukden, and Shanhaikwan, and partly to the fact that the route of the returning Shantung coolies does not lie through Peking, but down the Liao-tung peninsula and across the Gulf of Pechili to Chi-fu. Accordingly we find

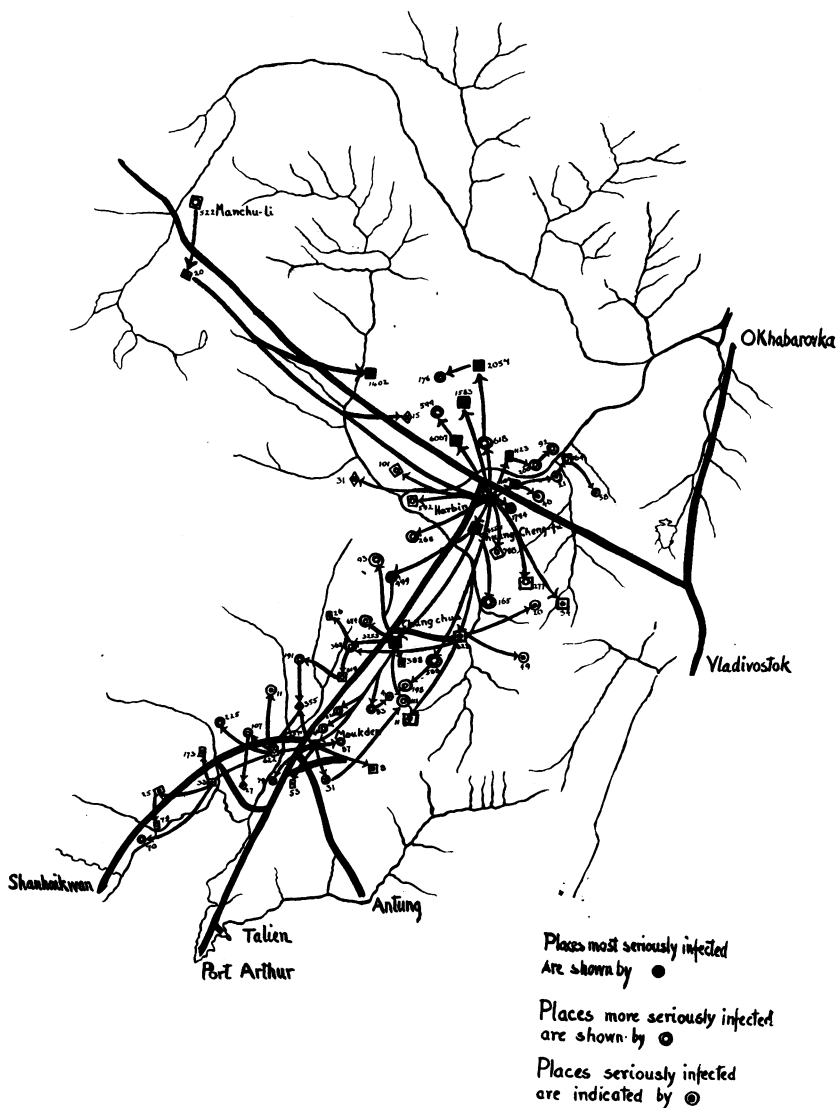


FIG. 1.

that cases occurred at Dairen (Dalny) and at Chi-fu and in its neighbourhood. I have no figures for those outbreaks.

The Japanese claim to themselves—and deserve—great credit for the rigorous quarantine measures by which they suppressed the plague in Dairen. These measures were perhaps applied with undue harshness to all Chinamen, no discrimination being made between respectable Chinese gentry and merchants and the wandering coolie class, but they were certainly effective. At one time they even talked of stretching a live wire across the whole peninsula. It must be remembered, however, that the Japanese, being at the end of the line, had ample warning and time for preparation, whereas Harbin was taken by surprise.

When—somewhat too late—a proper quarantine system was established in Fu-chia-tien (the native Harbin) it was well concerted, thoroughly applied, and very effective.

From the Liao-tung peninsula the Shantung men would make their way to Chi-fu, and perhaps other points along the coast, many of them in junks, the traffic of which cannot readily be inspected or controlled in a sanitary sense. Many cases occurred in Chi-fu, and some, I believe, in neighbouring villages. I have not the figures for Chi-fu, and there was no properly organized sanitary service here, though the doctors were allowed to search for cases in inns and poor-houses on their own initiative, but it is noteworthy that, so far as could be ascertained, not a single case occurred among the respectable Chinese residents or among the servants of the Europeans. Practically all the cases that occurred were among the coolie class, and the majority among coolies travelling to their homes in Shantung.

To illustrate the virulent infectivity of the disease I may relate the following incident. I had on one occasion visited, with Dr. Bennett, the plague hospital, in which at the time there were only two patients. We then visited an old cigarette factory, which was being used as a lodging-house for coolies passing through the town, and found there six men sitting together on a k'ang some 4 ft. square. They made no complaint and did not look particularly ill, but hearing one of them cough, I suggested that we should make him spit into a piece of paper. He was spitting blood. We made the others spit also. They were all spitting blood. The whole six were dead by the evening of the following day.

The extent to which villages in Shantung were infected by those who reached their homes is not known. The records which are avail-

able concern Manchuria only, but we heard no more of plague after the end of March.

A glance at the diagram here exhibited (fig. 2) shows that, from its first recorded appearance on October 25, till nearly the end of December, the plague made very little progress, though probably not all the cases that occurred were recorded at first. From about December 25 to the end of January the total rose in a steep curve, corresponding to the rush homeward of coolies returning to Shantung for the New Year, the climax being January 29, on which day more than 1,000 cases occurred. It will be seen that on about seven occasions the daily total approached or exceeded 1,000. A decline set in about the middle of February, a sudden drop occurred at the beginning of March, and at the end of the month the epidemic had almost entirely ceased.

The bacillus isolated and cultured by numerous bacteriologists in the course of this epidemic is specifically identical with the *Bacillus pestis*, isolated from previous epidemics of plague, which have been mainly or exclusively of the bubonic type. The strain isolated in Harbin was of a highly virulent type, rapidly producing septicæmic plague when injected into animals, but not more virulent *per se* than certain strains which have previously been isolated in bubonic outbreaks. There is no evidence whatever that the decline or cessation of the outbreak was due to any loss of virulence of the bacillus.

The epidemic was almost without exception one of primary pneumonic plague. Not a single bubonic case was reported to the Conference, nor, though I travelled over the whole affected area and visited most of the principal centres of the disease, did I hear of any such. One or two cases of so-called intestinal plague, in which the fæces contained large numbers of a bipolar staining bacillus, were adduced, but we did not consider at the Conference that these were established by trustworthy evidence. Dr. Strong, who made twenty-five autopsies on plague cases in Moukden, considers that the fact that the œsophagus was found to be normal in every case examined is an argument against the occurrence of primary intestinal plague infection, since in many of these pneumonic cases plague bacilli must have been repeatedly swallowed in the bronchial secretions and saliva.

Practically 100 per cent. of all cases were fatal. Three recoveries under the use of repeated injections of serum were claimed by the Japanese in Dairen. I saw two of these patients who had been in

hospital, I think, thirty and forty-three days respectively. Both of them were emaciated and had severe bedsores and a feeble, very compressible pulse; one of the cases was certainly and admittedly complicated by advanced pulmonary tuberculosis. I cannot say whether these patients are still alive. The diagnosis had not, it seems, been very rigorously tested.

One case of phenomenal insusceptibility was introduced to the Conference, an aged Dr. Gu, who had treated more than 200 cases in a crowded building used as a native plague hospital in Fu-chia-tien, on the mediæval lines of native Chinese medicine—needling, slapping, pinching, &c. This heroic old gentleman, though he lost all his patients, bore the whole brunt of the epidemic and escaped unscathed, having throughout refused to wear a mask or take any personal precautions. There were some grounds for supposing that he may have come through an abortive attack.

Dr. Christie also brought before the Conference the case of a Mrs. Lin, who nursed five cases in succession, but herself escaped. There were circumstantial grounds for believing that she may have acted as a carrier, but this theory cannot be regarded as well established.

So far as could be ascertained, the chief, perhaps the sole, method of infection during the epidemic was the inhalation of plague bacilli expelled in droplets during the act of coughing, the risk to the person exposed bearing a direct relation to his proximity to the patient and the duration of exposure. Dr. Strong, who in collaboration with Dr. Teague exposed plates and guinea-pigs at varying distances from the mouths of plague patients, showed that during normal or even dyspnoëic respiration plague bacilli are not usually expelled, but that in the act of coughing they may be widely disseminated into the air surrounding the patient.

The incubation period of the disease varies from two to five days. A rise in temperature and an increased pulse-rate are the earliest symptoms observable, but the characteristic clinical symptom of the disease is the expulsion of thin blood-stained sputum, and an accurate diagnosis can of course only be made by bacteriological examination of this. The patient passes into a stuporous condition, and dies as a rule within forty-eight hours from the appearance of blood-stained sputum. Mucous râles may be heard in the thorax, but auscultatory diagnosis is of very little value, as the patient is usually dead before any gross lesions have time to develop in the lungs. The pulse becomes very feeble and compressible, and the patient dies of cardiac failure from the rapid development

CHART SHOWING THE PLAGUE DEATH RATES OCCURRING IN MANCHURIA DURING THE LAST SIX MONTHS.

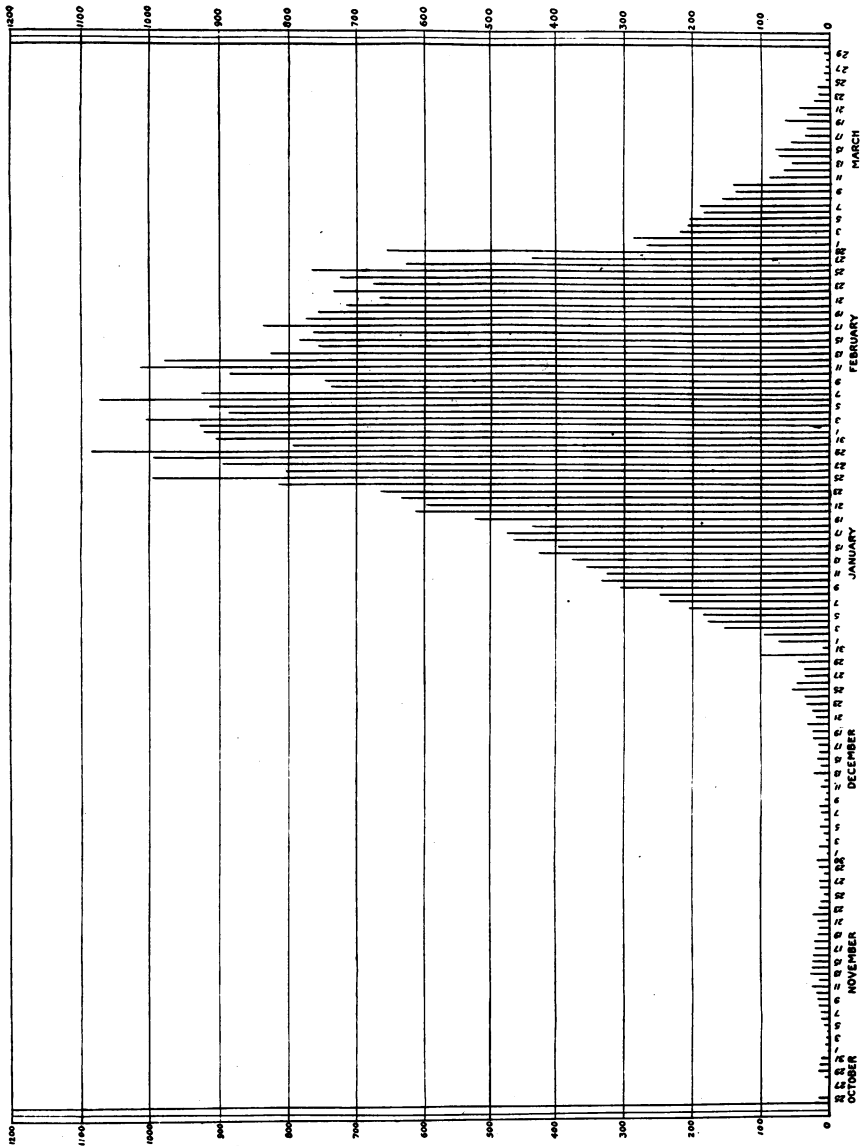


FIG. 2.

of toxæmia over the large area presented by the bronchial mucous membrane. There is a true bacteriæmia in practically all cases, and the toxin engendered is probably an endotoxin.

There is no evidence that fleas bore any part whatever in the spread of this epidemic, and despite of the crowded state of the native inns during the return of the coolies to Shantung, dark and ill-ventilated chambers in which men lie huddled on the k'angs like herrings in a barrel, and despite the fact that during the rigours of the Manchurian winter the coolie neither washes nor even removes his heavy clothing, fleas are apparently uncommon in the winter season in this region. I personally never observed a flea on any of the patients.

Neither—and this is a very remarkable fact—was a single case of rat infestation established. Many thousands of rats were examined during and after the epidemic by Russian, Japanese, and Chinese experts, but not one case of rat-plague was proved. One instance only was brought to the notice of the Conference, but this solitary case was not regarded by us as satisfactorily confirmed. On the other hand, fairly good circumstantial evidence was adduced of the occasional infection of donkeys, horses, and mules—animals which are often employed to turn oil-mills within enclosed buildings. The absence of rat infestation is perhaps the more remarkable, inasmuch as it has been repeatedly proved that living plague bacilli can be recovered from the mucous membrane of the mouth of plague corpses, buried or unburied, which have been more than three months dead, even from putrid corpses, though most corpses, especially if buried, would mostly be frozen in Manchuria. Professor Zabolotny told me in July that they were still finding corpses in Harbin from which the plague bacillus could be readily recovered. It might be thought that rats could become infected by devouring such corpses.

We can now discuss the causes which brought about the cessation of the epidemic.

I have already said that there is no evidence whatever that its decline was due to any loss of virulence in the bacillus. Neither does the decline appear to have been influenced by climatic conditions. It is true that the epidemic began to decline about the middle of February and subsided more rapidly during March, but a diminution in the number of cases was observable before there was any substantial abatement of the severe cold of Manchuria; and the cases that occurred in March were to the full as severe and fatal, and apparently quite as

infectious, as those that occurred in January, when the plague was at its height.

The main factor in the decline of the epidemic was probably the preventive measures enforced. These were either administrative measures, railway inspection and quarantine, isolation of patients and suspects, segregation and inspection of contacts, house-to-house visitation, cremation, the enforcement of personal precautions, &c.; or, in the numerous towns where such administrative measures were either not employed at all or were very inadequately carried out, a very efficient substitute was found—when once public opinion was awake to the terrors of the disease—in the crude efforts of the people to protect themselves. Commerce and social intercourse in infected towns came almost to a standstill. All intercourse was refused with members of infected houses, who were sometimes even forbidden to leave their homes, and were dependent for food on supplies deposited by friendly neighbours outside the house. I was told in Chi-fu that in one instance the local Tao-tai had drawn a cordon round an infected Shantung village, and would allow no one to leave it. A similar story is recorded of the village of Eyam in Derbyshire, in 1666. Isolation on these lines, enforced by public opinion, doubtless explains, to some extent, the limitation of plague outbreaks in mediæval times.

A pathetic episode was related to me in Schuang-cheng-fu. A young Manchu girl, an heiress, was the sole survivor of a household of seven persons. She went to the house of her betrothed and begged admission, but was repulsed by his mother. She then returned to her own home, set fire to the house, and perished in the flames.

Another factor in the decline of the outbreak was probably the diminution of traffic by rail and road that ensued when the homeward-bound Shantung coolies had reached their destination.

The question whether such an epidemic is likely to recur is of importance. I think we may infer that a plague epidemic of purely pneumonic type with absence of rat infestation is, despite the virulence of its infectivity, relatively amenable to control by administrative methods. In India it is comparatively useless to isolate the patient and his contacts. The practical problem—almost insoluble—is control of the rat epizootic, and wholesale evacuation appears to be the sole method of real value. In Manchuria the disease may again make its appearance under similar conditions, but the railway and civil authorities ought not again to be taken by surprise as they were on this occasion. We may be sure that a sound system of railway inspection and

quarantine will be in force if plague shows itself again another year, and I know that an excellent sanitary service has been devised for Harbin and Moukden, and other places along the route, by my friend and colleague, Dr. Wu Lien Teh. No subsequent outbreak is likely to attain the dimensions of that with which we have been dealing to-night.

There are several aspects of this question which I have been unable, for lack of time, to consider, but I must not trespass further on your indulgence. I shall endeavour to deal with other points if they are raised in the course of the discussion.

DISCUSSION.

The CHAIRMAN (Sir Shirley Murphy) said he felt sure all present would wish to join in a cordial vote of thanks to Dr. Farrar for his most interesting paper. The Section did not often have a story from an infected area in which the details were described in so graphic a manner. The author had had the advantage of seeing plague in India, and he was thus able to compare the Indian plague with the Chinese plague. In India the disease was largely bubonic and exceptionally pneumonic; in China it was apparently wholly pneumonic. The absence of rat infestation which the author noticed in China was another point to bear in mind. The feature which had interested him particularly was the fact that this Manchurian epidemic was brought to an end quickly. As far as he knew it was a general rule that when an epidemic malady was dying out the fatality-rate was gradually reduced. Towards the end of an epidemic one found that out of a given number of people attacked the majority recovered. But matters seemed to have been different in China, for, unless he misunderstood the author, all the way through nearly everybody who was attacked died of the disease. Bearing that in mind, he was puzzled to know what it was which brought the epidemic to an end. Dr. Farrar was of opinion that this was due to administrative efforts. It was astonishing that among an Asiatic race like the Chinese there should be such efficient administration as to enable complete control of the movements of people necessary for stamping out the disease to be exercised, for he supposed it was largely a question of control of movements of infected persons. There was one item of considerable comfort, namely, that a large factor in dealing with the plague and its arrest was the wearing of the mask, which seemed to have been a preventive of infection in a large degree.

Dr. SANDWICH said he was glad to see the reference by the author to that wonderful funeral oration delivered by the Viceroy of Manchuria on the death of Dr. Jackson, of Moukden. He did not think anything in the history, even

of the Epidemiological Society, was more wonderful than the fact that the Viceroy should be calling on the spirit not of the "foreign devil," but of Dr. Jackson, who had helped them so much in life, asking him to assist them now. It was really a wonderful peroration. He would very much like to ask whether Dr. Farrar could throw light on one or two points of doubt. The first was, as to how plague was communicated from the marmot to man. In the case of pneumonic plague it was known that the plague bacillus was coughed up and transferred by means of the air directly from man to man. This was easy to understand. It had been said now and on former occasions that the marmot spread disease; this might be accepted as an epidemiological fact, but one would like to know how the indiscreet hunters, who dug the marmot out, succeeded in catching pneumonic plague, because it appeared from the paper that there was no bubonic plague at the origin of the outbreak. The author said that the disease was pneumonic from the beginning, at least as far as information could be obtained, going back to October. One must suppose that the first individual or individuals caught the plague, of the pneumonic form (or the septicæmic form), from the marmot. He did not throw the smallest doubt on the fact that they did so, but he would like to know, if possible, how the plague bacillus got from the marmot to the lungs of the man. Bearing in mind the fact already referred to, that rats and rat-fleas had nothing to do with the present story, he would like to ask, as a matter of curiosity, if the marmots had fleas, and, if so, whether they had been studied. Also, as so much had been said about the over-crowding of the people, and there was no doubt that that was how they gave pneumonic plague to each other, if there was a human flea season. When the weather was not so cold was there a time recognized as the breeding time for human fleas? All those who had interested themselves in fleas would know there was a season for them—the human variety as well as others. His next question was, had the plague bacillus ever been found in or on a marmot? This was a very vital point. In the summer he privately asked Dr. Petrie this question, and he answered that he thought there had been no absolute proof of it up to date. He (Dr. Sandwith) was not suggesting that the marmot was not responsible, but if it was the idea that this animal should be killed off by thousands, it would be convenient if it were first ascertained whether it did or did not harbour the plague bacillus. He understood that other experiments were to be carried out, and perhaps Dr. Farrar would be able to enlighten the meeting on that point. He would like to hear more about the masks to which reference had been made. He wanted to know, in case somebody with pneumonic plague came his way—which had happened before now—who were the people who should wear the masks? Patients should be compelled to wear them; he believed that the most recent practice at some consumption hospitals was for patients to wear them while being examined. And he thought it right that doctors and nurses should wear them. But was it necessary for the people who were parading the streets, policemen, &c., to

wear them also? He did not suppose Dr. Farrar would wish everybody to wear masks, but as he had come straight from the line of battle he could perhaps tell the meeting how to avoid the bullets better than anyone else. And what kind of masks should they be? He had been interested in hearing a distinguished Local Government Board official mentioning quarantine with some faint amount of praise. He had suffered so much from Dr. Farrar's official ancestors, who had always regarded quarantine as anathema, that it was agreeable to find a man who had come back from an epidemic with some faith in the measure. Land quarantine could not be praised as a general measure, because it was usually carried out far too late. There were certain occasions when it might be useful if it included isolation and thorough inspection. Dr. Farrar had had to deal, together with his Chinese colleague, whose methods were different, with a mortality of 100 per cent. It did not matter much about the methods when the mortality was the same. But the point was that all the people affected died, and therefore they could not carry the infection. Now it happened occasionally that a case of pneumonic plague recovered, though it had only happened once in his experience to meet with such a case. He had sometimes quoted that as an instance of how absurd quarantine would be, because he had seen a person living in a hospital for three weeks with less cough than was manifested by some in the room that evening, and yet spitting up a little sputum which was harmless in appearance but so virulent in character that it killed a guinea-pig every day for three weeks. There was no appearance of blood; it was pneumonic plague in convalescence. That, he had always thought, would be the sort of person to evade successfully all quarantine rules or inspection, because, as Dr. Farrar said, one could not tell by auscultation or percussion that the individual was ill. The last remark of Dr. Farrar was extremely interesting and useful, namely, the comparison of the control of pneumonic plague with that of bubonic plague. In the former one had the great advantage, so far as the spread of the disease was concerned, that the person afflicted with pneumonic plague died and the infection died with him, whereas the rat and the nimble flea, when infected, escaped and carried the plague to fresh human beings or to fresh rats.

Dr. C. J. MARTIN, F.R.S., said he was sure those present would agree that they had listened to an excellent little account of the happenings in Manchuria last winter. He had had the opportunity of reading through the whole of the minutes of the Conference in Moukden, and he could confidently say that this paper contained all essential matter and was, moreover, much better reading than those minutes. Indeed, as far as picturesqueness and literary splendour were concerned, he was reminded by it of Defoe. Two or three points in the contribution interested him considerably. One was, that this very large epidemic had demonstrated how easy, under very disadvantageous conditions, it was to deal with pneumonic plague. This had

been the case with smaller outbreaks elsewhere; a priori, from what one knew of the aetiology of the disease, the means of spread of pneumonic plague and the sensitiveness of the plague bacillus, there should be no great difficulty. Although the immediate neighbourhood of the patient was very dangerous, the range of fire compared, say, with small-pox was short. At the time when there was some excitement about plague being introduced amongst the rats in this country he ventured to point out that though only a rat infection, it was a very much more serious matter than if confined to human cases of the pneumonic form, as the latter was easily tackled in a country like this, with all the sanitary organizations which existed; whereas rats were working underground, and it was very difficult to get to windward of them. It was very interesting to learn that the investigators had found no rat plague whatever during the outbreak now described. He believed that the chance of rats becoming infected by eating plague corpses or plague-contaminated material was extremely trivial, and that the whole transfer of rat-plague in Nature from rat to rat was indirectly by means of rat-fleas. He wished to ask Dr. Farrar if dyspnoea was at all striking towards the latter part of the illness. In some of the cases he had seen himself, dyspnoea had been very marked, and to an extent which was quite unaccountable by the amount of pneumonia detectable, and air was entering both lungs perfectly well. Except in cases of pulmonary embolism, he had never seen such severe dyspnoea as in some cases of pneumonic plague.

Fleet-Surgeon W. E. HOME said that members would be glad to hear an account of that large and dangerous epidemic in Manchuria, which caused so much anxiety. In the beginning of the year it was impossible to forecast that the epidemic would stop so suddenly. When Dr. Farrar went out many were anxious as to whether he would come back, because at that time it was a dangerous situation. It was interesting to find the author so confident that the cause of the cessation of the epidemic was the adoption of the sanitary precautions. He remembered in the old days that efforts were made to stop the epidemic of plague in Hong Kong, but at Canton, where nothing of the sort was being done, it stopped a fortnight sooner than in Hong Kong. He asked what was the date of the Chinese New Year. It was well known that the Chinese were very anxious to get back to their own homes by the New Year, and that the gates of the cities were kept open for that purpose. If the New Year was on January 9, and the epidemic began outside Harbin on January 2, it was surprising that the coolies should have been so backward in getting home. One would have thought the Chinamen would have passed there long before. Of course, the incubation period had to be allowed for. He would like to know if the epidemic ceased suddenly in all the places visited by it. It seemed to him as if there was something about the epidemic itself which caused it to cease, though he had not first-hand information, as Dr. Farrar had. As an Indian said a long time ago, "You

make a great deal of fuss about stopping plague, but in time Allah will take it away and one of the sahibs will get the credit for it, and perhaps the C.S.I." Dr. Farrar mentioned a sound system of quarantine. He would be glad to know what that was. If the author were medical officer at Harbin and was afraid that plague was coming through, what would he do? Would he take all the people as they came down, separate them and put them into railway carriages, keeping them there for three or four days or a week, and then if they did not develop anything let them go on?

Dr. W. H. HAMER desired to ask the author about the case of Mrs. Lin. On p. 10 it was stated that "There were circumstantial grounds for believing that she may have acted as a carrier." Dr. Farrar did not say what the grounds were; it seemed that a French paper said Mrs. Lin infected eleven people, but it was now only suggested that she may have infected three. It would be interesting to know what the grounds were for thinking she infected these three. The outbreak now described was practically unique in the recent literature, inasmuch as of all the thousands of cases which had occurred only three were supposed to be infected by a healthy bacillus carrier. It would be a great relief if those three could be got rid of, because, as Dr. Farrar said (p. 3), it was "the limitation of the epidemic, rather than its extension, which required explanation." If one were compelled to believe in healthy bacillus carriers, the difficulty here was much increased. This was, of course, true of all epidemics; as soon as the bacillus carriers became particularly numerous the prevalence came to an end.

Mr. GOADBY said that Dr. Farrar had not given any suggestion as to the way in which healthy persons could act as carriers, and he wondered if, during the bacteriological investigation, the mouths and throats of these persons had been examined in order to learn if they were harbourers of bacilli, as the healthy person was known to carry the diphtheria bacillus. In relation to the bubonic type of plague, he referred to an interesting picture by an old Dutch painter in the Louvre, portraying one of the plagues of Egypt. It was painted in the early part of the seventeenth century, and showed dead rats lying all over the street and in the houses.

Dr. O. KENTISH WRIGHT said it was very striking to one who had not seen plague, that the account of this epidemic seemed to differ markedly from the account which one heard of the Indian bubonic plague, and this made one wonder if the bacillus had been exhaustively investigated with the view of proving its identity with the bacillus of bubonic plague. He would like to hear if rats had been successfully infected artificially, also if the species of rat found in China was the same as that which had been proved to be infected in India. He would be glad if Dr. Farrar would state the conditions under which these cases of plague were nursed in the hospital, particularly

with regard to ventilation. Where he was now working a good deal had been done in the treatment of various acute specific diseases in the open air, in the same way as phthisis was now generally treated. Cases of pneumonia were included in this method. He therefore wondered whether in the hospitals in Manchuria the ventilation was very free; or whether the temperature was too low all the year round to permit this. He asked the question particularly with reference to the danger to the people who were engaged in looking after the patients, because since, at his institution, open-air treatment had been adopted in practically all cases of specific fevers, it was found that the attack-rate on the nurses was very much reduced. In connexion with the safety of those who looked after the cases, he would like to know if inoculation against plague was practised to any great extent.

Dr. BUTLER said he would like to utter his note of scepticism, which had been echoed by others, as to the efficacy of the sanitary administration in terminating the epidemic in Manchuria. If one looked at the diagram exhibited, and remembered what Dr. Farrar said, that at the commencement of the epidemic there was a practical absence of sanitary administration over an area where it would be more difficult to establish it than in any other part of the globe, and contrasted the result—the symmetrical decline in a few months—with what could be obtained in this country with experience and a long-established sanitary service, in dealing with an epidemic whose infectivity was not unlike that described in the paper, there was room for scepticism. We had a disease largely communicated from the expectoration, analogous in its rapid diffusion to measles, or small-pox, breaking out in an unvaccinated community, and when it was remembered how hopeless a task it was to limit epidemics of that kind by the methods which were possible to us here, it would be remarkable if, under the extremely difficult circumstances in China, one could organize a service which would bring about so excellent and rapid a result. Of course, there was the point in favour of such administration that they were dealing with a disease which immobilized almost all who were attacked; there were very rapid effects, and universal death. That undoubtedly made the problem much easier than it would be where there were mild cases, which went about and diffused the disease among others. Still, it was difficult to believe that administrative measures could have achieved what had been depicted.

Mr. T. P. BEDDOES asked what was the explanation of the three suckling children not catching the plague, though their mothers were suffering from it. Was it suggested that the milk had a protective influence? If such an explanation as that were forthcoming, it would be of interest. Or was it simply a coincidence that the children were not infected?

Dr. FARRAR, in reply, said he would try to deal with all the points which had been raised, but as he was not a bacteriologist, nor an expert in any sense, he could not hope to do full justice to some of the questions. Dr. Sandwith

asked the very pertinent question, how did the disease pass from the marmot to man? It seemed highly probable that the disease was started in the human from the marmot in the first instance; but the Conference never had any really definite evidence before it that such was the case. It was considered to be a point requiring special investigation. He asked Dr. Zabolotny how infection might occur, and he said that men handling the skin of infected animals might easily put their fingers in their mouths, and in that way infect themselves. It appeared that the experienced Mongol hunters preferred to run the animal down with dogs in the open. The new hands, however, mostly Shantung coolies, who were not such good hunters, preferred digging down into the burrow of the animal and hauling it out by means of a wire noose round its neck, the idea being to avoid injuring the skin. It was easy to imagine that a plague-infected marmot caught in that way might cough in the face of the captor, and so give him the plague. Still, that problem remained as yet unsolved. After the Conference, Dr. Chwan, Dr. Zabolotny and some assistants, conducted a mixed Russian and Chinese expedition to investigate the problem. Dr. Sandwith also raised the question of the marmot-flea. Dr. Petrie found a special kind of flea on the marmot, which the members of the Conference christened *Pulex Petrii*. But he believed a Russian investigator had already described that particular flea, though Dr. Petrie was not aware of this. At the Conference the question of the human variety of flea was not brought up. Apparently all the experts there—and they included several noted bacteriologists—agreed in discounting the human flea as a factor in the matter. But Dr. Andrew, of Tong Shan, was there, and he worked out the flea prevalence in the bubonic outbreak which they had a year or two back. It was said that the prevalence was in the autumn, and that the rat was a factor. It seemed to him (Dr. Farrar) that the flea prevalence period in Manchuria was not in the winter. Absolute identification of the plague bacillus in the marmot had not yet been effected, he believed, but at Moukden they had several marmots, and investigated them; the Japanese also went into the question. It was found that the marmot was highly susceptible to plague infection, even more so than the guinea-pig. With regard to the kind of mask to wear in the presence of plague, apparently the three-tail gauze bandage covering the mouth and nose, composed of a kind of material which could be burned at the end of the day, was the best. It should not be very thick, as it was very uncomfortable to wear a mask for any length of time. It was absolutely essential for those who would visit patients to wear a mask, as any patient might cough in one's face. In answer to Dr. Sandwith's question, as to what he meant by quarantine, he would say it meant either putting persons in railway carriages, or into a hotel, or otherwise isolating them and watching them for some days, at all events well over the incubation period; that would constitute a very effective quarantine, in his view. The Chinese railway people spent a lot of money in quarantining first-class and second-class passengers at Shanhaikwan. The

quarantine, when once started, was very strict. Dr. Martin had raised the question of the range of fire. Dr. Strong made some crucial and very careful experiments, in which he exposed plates at various ranges, and found that during quiet breathing, and even during dyspnoëic breathing, the plates generally were not infected; but in coughing the bacilli were expelled to a distance of at least 4 ft. He believed Dr. Strong also infected guinea-pigs at various distances from the patient's mouth. What Dr. Martin said about rats was very true. If one had rats to deal with in connexion with plague or other acute infection, it was dangerous; but if a person was ill with pneumonic plague, he was very ill, and soon died; he would not wander about and infect other persons. Moreover, whilst he was ill, once it was known he had plague no one would go near him, and therefore the outbreak would tend to self-limitation. He was glad to hear Dr. Martin's opinion that rats did not get plague by ingestion. It was possible in the laboratory to make rats take plague by ingestion, but he did not believe it was easy even there, and it did not commonly take place naturally. The Russians attached some importance to the fact that human bones had been found in tarabagan burrows, but this did not prove that the animals contracted plague by infection. In answer to Dr. Martin's question about dyspnoëa, that symptom was striking in certain cases. Dr. Strong did twenty-five autopsies on plague cases in Moukden, which was interesting, as it was the first time autopsies had been permitted in China, and was a historical fact of some importance. Dr. Strong said that in every case the glands chiefly affected were those at the bifurcation of the trachea. There was also a general lobular infection of the whole of the mucous membrane of the lungs. If the patient lived long enough, there were found to be further lobar changes, and there might be dyspnoëa. Dyspnoëa was found, but as a rule it was not a very striking feature of the disease; the patients usually passed into a condition of stupor and died before the lungs were profoundly affected. A very soft, compressible pulse seemed to be a very characteristic feature of the disease, and it was not uncommon for patients to die when being raised up in order to be fed. Cardiac failure or collapse occurred from the intensity of the toxæmia.

Fleet-Surgeon Home raised the question of quarantine, and in reply to him he could only say that much depended on the incubation period, which was from two to five days. In Fu-chia-tien they made use of railway carriages. That place was on the Russian railway line. Those who could isolate contacts in groups found it very useful for quarantine purposes. Dr. Hamer challenged him as to the case of their friend Mrs. Lin. Dr. Christie, of Moukden, one of the oldest missionaries in China, related the case of Mrs. Lin. That lady nursed five people, but she made three visits to different families. One of the people she was nursing died in one family. She went to another house and another person was infected, and so in a third family, and it might have been Mrs. Lin who took the infection. There was circumstantial evidence which satisfied Dr. Christie, but the case was never bacteriologically proved.

Mr. Goadby raised a question on what was said in the paper about the range of infection, and about it being against the idea of carriers. Apparently during ordinary quiet breathing it was not easy to infect plates exposed at a distance of 6 in. to 3 ft. from the patient. The bacilli were only expelled by coughing. It was thought that Mrs. Lin might have had a mild attack, and in coughing might have infected the people she visited. It was never bacteriologically proved that Mrs. Lin ever had plague, and it was not proved that she was a carrier. He gave the incident as it was clinically observed. Dr. Kentish Wright asked if the bacillus had been investigated, and wondered whether there was satisfactory evidence that the *Bacillus pestis* was the same as the bacillus which caused the bubonic epidemics. This he would answer emphatically in the affirmative. The evidence satisfied the bacteriologists there, who considered that morphologically, culturally, and in every respect the *Bacillus pestis* observed in the Manchurian epidemic was identical with the bacillus investigated in other outbreaks. Dr. Strong was very definite on the point that it was not *per se* more virulent when injected into guinea-pigs than certain strains which had been isolated from epidemics. There were various strains of plague bacillus, some of which were very mild, but some bubonic strains were very virulent, apparently as virulent when injected into animals as was the Manchurian strain. With regard to the open-air treatment, even if the patients could stand it, he did not think Dr. Kentish Wright would like to visit patients in the open air, especially when the thermometer stood at 40° below zero F. Moreover, there might also be an east wind blowing. In Manchuria on cold days the conditions were terrific. With regard to inoculation, Haffkine's prophylactic was tried a good deal. Dr. Martin inoculated him before he went out, and Dr. Petrie gave him another dose in the train. There was quite a long discussion on that point at the Conference. Galeotti was holding out for his serum, Martini for killed agar cultures, and Haffkine for Haffkine's prophylactic. Certainly many patients who had been inoculated subsequently contracted plague, and died. Marmontoff had been injected three times, Dr. Jackson, he believed, twice. Thirty-two patients inoculated by Haffkine at Harbin contracted plague and died. There seemed to be some evidence that those inoculated were somewhat less liable to take the disease, but he did not think the Haffkine injection was much of a success. If one had been recently inoculated, and in the negative phase, one might, some thought, be even more liable to plague than without such inoculation. He would like Dr. Martin to give the meeting some supplementary information about this. Dr. Strong fought hard for the use of attenuated living cultures. Dr. Strong had had exceptionally good facilities for testing this method. He was Government Surgeon in Manila, and his vaccine was a living culture attenuated with alcohol. After preliminary experiments on guinea-pigs he satisfied himself, as the result of inoculation in 200 criminals who had been sentenced to death, that the attenuated living culture was as harmless as ordinary vaccine for variola.

Sixty-four of these criminals were afterwards inoculated with virulent plague culture and only sixteen died. They voluntarily submitted to the experiment as the alternative of execution. Though the method was not sufficiently appreciated by the Conference, he himself thought it held out great promise, and if he were going to face plague again he would have the attenuated living cultures inoculated. With regard to Dr. Butler's remarks, he thought the members present had scarcely appreciated the fact that he said the crude efforts of the people had done much to protect the people from plague. A person with plague was so ill, and all others had such a fright lest they should take it, that there was very little contact. People would not go near a house where plague was, and when folks were roused, isolation thus effected was as effective as orthodox sanitary measures. In Fu-chia-tien there was a very effective organization; the town was split into four divisions, and no person was allowed to go from one part of the town to another unless he or she had a pass. The divisions were indicated by different colours worn on the sleeve. Shuang-cheng-fu was not a crowded and dirty place, but a large, prosperous Tartar town, with wide streets, yet the plague raged as badly there as it did in the crowded and squalid slums of Fu-chia-tien. In answer to the question of Mr. Beddoes, as to the babies at the breast not getting plague, the two extremes of life seemed to be immune from attack. Possibly these babies did not receive the mothers' sputum, as she would cough over their heads. The Chinese New Year was on January 30 this year.

Dr. C. J. MARTIN, F.R.S., complying with the request for further remarks, said he was interested in the criticisms of Dr. Farrar's statement about the cause of the ending of the epidemic. Dr. Farrar had, however, pointed out that it was the means adopted by the people which put an end to it, quite as much as the measures taken by the authorities. Dr. Farrar might have mentioned the method used by the Buriats in Mongolia, which was, from the standpoint of the public health, an excellent sanitary measure, but rather drastic. If they recognized a case of the disease the patient was sewn up in his tent, and no one went near it until there was no more smoke. When that kind of procedure was operative one did not require medical officers of health. It showed quite a virile public spirit. With regard to the means of vaccination, he thought Dr. Farrar was probably right in his suspicions, that the method advocated by Strong, of using attenuated cultures of living plague, was probably more efficient than any means yet known with dead bacilli. But he (Dr. Martin) did not think there was any future for attenuated cultures. No one would take the responsibility of putting attenuated plague cultures into people so long as one could not guarantee that they might not light up. There was only one culture of plague which he had had, out of several hundred strains, of which he had not been able again to raise the virulence by suitable measures; and while that was so no Government would take the responsibility. One might be sure that there was no reasonable probability of

it doing harm, but if a vaccinated person subsequently contracted plague, it would be attributed to the vaccination. Another question was that concerning the negative phase. He could only speak of it in connexion with rats. In them, with any reasonable vaccinating dose there was no negative phase, and the protection started the next day after the inoculation of a small dose of the contents of the plague bacillus. Therefore, if one could translate those results in the case of rats to man it was safe to vaccinate in the presence of an epidemic; and statistics in villages in India indicated that this was the case. It was very difficult to induce people to be inoculated if there was no plague within 100 miles; it was easier to get them inoculated when the plague had begun; and it was a useful measure in the actual presence of an epidemic. He did not know to what extent one dose of Haffkine's fluid would protect against pneumonic plague; there were no figures available on this point.