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NORTH MANCHURIAN PLAGUE PREVENTION SERVICE

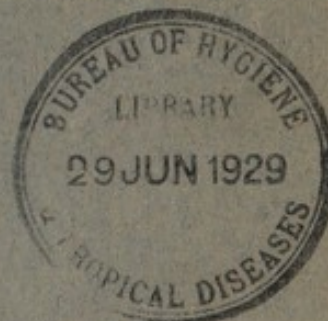
Wu Lien-Teh, Director

**STUDIES UPON THE PLAGUE SITUATION
IN NORTH CHINA**

BY

WU LIEN-TEH, R. POLLITZER,
LIN CHIA-SWEE AND H. M. JETTMAR

- I. General Survey of Plague Outbreaks and their Suppression
- II. Clinical and Laboratory Observations during the 1928
Tungliao Plague Outbreak
- III. Report on an Expedition into the Plague Focus of Tungliao
- IV. Summary and General Conclusions
- V. Appendices
- VI. Illustrations and Map



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Harbin (China), North Manchurian Plague Prevention Service.
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Manchurian Plague Prevention Service, Harbin

I. GENERAL SURVEY OF THE OUTBREAKS
AND THEIR SUPPRESSION

WU LIEN-TEH

- A. Sketch of the History of Plague in North-East Asia.
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A. SKETCH OF THE HISTORY OF PLAGUE IN NORTH-EAST ASIA

This chapter is mainly devoted to a description of the 1928 plague outbreak in and near the Tungliao District (former Mongolian territory). However, it is at first necessary to discuss former epidemics and to investigate what possible connections might exist between the several regions suspected or known to have been visited by the disease.

The following areas need be mentioned:

1. *Transbaikalia (and adjacent part of North-West Manchuria).*

Complete information upon this matter has already been published in my "Treatise on Pneumonic Plague" (1) up to the year 1925. A few additional cases were noted in 1926, while the year 1927 was clear. One doubtful instance was recorded in the summer of 1928 (2). In December 1928, reliable news reached us about an outbreak of pneumonic plague involving 17 cases in a locality 300 miles south of Petrovski Zavod, a station of the Chita-Verkhneudinsk Rly. This territory was formerly visited by the disease.

It is hardly necessary to mention that plague is enzootic among the tarabagans (Siberian marmots) abounding in Transbaikalia especially, and spread to human beings who come in contact with these hunted animals. The main vector is the tarabagan flea, *Oropsylla silantiewi* (formerly *Ceratophyllus S.*). The early victims practically always suffer from bubonic plague (with a predilection for the axillary regions). In spite of an undoubted tendency of the infection to spread from man to man and to assume pneumonic features, the outbreaks are as rule limited, and quickly detected by an alert anti-plague organisation. Only twice, in 1910 and 1920, was the plague early imported into North-West Manchuria, where it found ample fuel for further spread. Whether this was due solely to extraordinary conditions which made a sanitary survey difficult (as was the case in these years) or whether a periodical increase of the epizootics was concerned as well is at present difficult to decide.

Though our records only reach back to the year 1863, plague in Transbaikalia is certainly of very old age.

2. *Outer Mongolia.*

The same evidently holds true of Outer Mongolia. Here also the earliest tales about plague outbreaks can be traced to the sixties of the nineteenth century. Unlike Transbaikalia only occasional reports are available, but there is every reason to assume that plague manifestations occurring away from large settlements and common traffic routes remain unrecorded.

The scanty information at our disposal (1, 2) may with advantage be analysed under three headings:

a. *Districts adjacent to the Transbaikalia endemic area.*

Some data regarding pest manifestations in this region have been collected in the "Treatise" while more satisfactory information about an outbreak occurring in 1927 in the Chechan-Han District (now called Oupuor-Chan District) is embodied in Volume VI of our Plague Prevention Reports (2). News about a further visitation of this area, kindly furnished by Dr. Shastin (Urga, 3), is as follows:

On August 31, 1928, information reached Urga about the appearance of the "tarabagan disease" in the Oupuor district. A Government Anti-plague Commission sent an expedition which found 10 plague cases during September and the first half of October. No further information after that.

b. *Western districts of Outer Mongolia.*

Here also some outbreaks have been reported in the past (1), the most westerly being not far from Kobdo. It appears that the western as well as the north-eastern regions of Outer Mongolia abound in tarabagans. Those near Kobdo, possessing a black fur, seem to belong to a special sub-group of the *Arctomys bobac*, but detailed epidemiological information is still wanting.

In Dr. Shastin's letter (3) interesting information is given of an outbreak in 1928 occurring near the capital Urga (now called Ulan Bator Choto): On September 3 two sick children were admitted into the Municipal Hospital, having arrived the evening before from the Mishigun district west of Urga. They were the offspring of a Buriat tarabagan hunter, named Bazar. This man who used to live in the capital, had arranged small tarabagan expedition in summer to the Mishigun area. While on this trip he died towards the end of August after a few days' illness. His wife, who had visited him with their two children, in turn fell sick and died on the way back to Urga. The next victim was one of the two fellow-hunters of Bazar. His case was followed by those of the children while the other hunter remained healthy. The two children died during the night of September 4-5, having suffered from *pneumonic* plague as confirmed by autopsy and cultural tests.

Besides taking appropriate measures in Urga itself (including erection of a quarantine station against Mishigun and disinfection of tarabagan skins) an expedition was sent out to the plague area. This reported a total of 24 plague cases (including the above mentioned) in four apparently independent foci. Though only pneumonic cases were actually seen by the doctors it appears that these had been preceded by bubonic ones; all ended fatally.

Material from tarabagans found dead in the fields proved positive. Attention was also directed upon the five camels (*C. bactrianus*) which had transported the sick to Urga. One of these animals died spontaneously while a second was killed in the agonal stage. Cultures of bipolar-staining bacilli were obtained from both but proof of the plague nature of these is not yet conclusive.

c. *South-Eastern parts of Outer Mongolia.*

Nothing is known about this epidemiologically interesting region except some vague information that for several years up to 1927 plague outbreaks were not



infrequent 400 versts (ca. 270 miles) south of the Kerulen River. While in areas a and b the outbreaks are undoubtedly all tarabagan-caused we possess no reliable information as to the presence of these rodents in the South-Eastern parts of Outer Mongolia and their etiological rôle.

3. Inner Mongolia.

a. *Eastern parts.* The same holds true about the eastern parts of Inner Mongolia. For this region we have no data whatsoever as to the incidence of even human cases. Nevertheless it deserves serious attention because plague outbreaks occurring in adjacent districts seem traceable to it. This evidently holds true of the two following regions:

i. *Tungliao district and adjacent parts*, visited by the disease since 1924. This will be discussed later on.

ii. *The Weichang district.* This area, though geographically forming part of China proper (Chihli Province) belongs epidemiologically to Inner Mongolia: The missionaries reporting outbreaks there since 1888 had stated expressly that the disease came from the north (4). Zabolotny, who like Matignon visited the district, was inclined to connect the outbreaks occurring there annually with the tarabagan, but based his opinion upon the rôle ascribed to this animal farther north. Matignon (5) says he has observed no mortality among rats or other animals. As far as can be judged from the description given by these authors, the houses, habits of life, etc. of the inhabitants (partly Chinese, partly settled-down Mongols) are similar to those noted in the Tungliao district. No further outbreaks have been observed in this region since 1899.

Before passing to the other parts of Inner Mongolia it may be well to discuss two other areas into which plague is believed to have been imported from the endemic south but which are situated near enough to Inner Mongolia to assume a theoretical connection with the latter focus. These are:

1. *South Manchuria proper.* Here plague outbreaks unconnected with the tarabagan were observed from 1899-1907, the disease being either restricted to Newchwang or spreading a little northwards from this center. Only once (in 1905) were 13 rats found infected among 23,000 examined in S. Manchuria while numerous examinations made in the years 1906 and 1907 remained negative. As established at the time of the 1910-11 epidemic—which like that of 1921 had been imported from North Manchuria—only 6% *Ep. rattus* were present among over 30,000 rodents examined, the rest being *Epimys norvegicus*. Their fleas were *X. cheopis* and *Ceratophyllus* sp. (apparently *anisus*, 1). The rarity or even absence of rat plague in the early epidemics suggests a possible transmission from man to man. In fact we find that pneumonic cases were usually met with and sometimes even preponderated. In the transmission of bubonic and septicemic plague human parasites might have played a rôle.

Newchwang being a stopping place for travellers from both south and north, it would seem theoretically possible for the disease to be imported from one or the other; in both cases it might have secondarily spread to adjacent, less visited,

settlements. The fact, however, that throughout the whole time cases farther inland *en route* from Inner Mongolia were totally absent suggests that there is no reason for revising the theory of a southern origin of the early outbreaks in South Manchuria proper.

2. *Tongshan*. The same evidently holds true of the solitary outbreak occurring in 1903 in the inland mining center of Tongshan (on the Peking-Mukden Rly.). It is true that Dr. Moorhead of the Mining and Railway Hospital, Tongshan, ascribed it to an immigration of rats from the North-east in spring of 1903 (6). But this was not confirmed and all evidence points to an importation from Southern sources, e.g. through Cantonese immigrants, baggage or foodstuffs.

No observations upon rats were carried out during the epidemic. Andrews (7), investigating the rats from June, 1909 to September, 1910, noticed only *E. norvegicus* and *X. cheopis*.

b. *Central parts*. While little is known about the eastern parts of Inner Mongolia, our information regarding the central portions of this country is more satisfactory. Here also the disease tends to spread to the more populated eastern districts and, as far as our incomplete historical studies show, such an invasion did take place in the past. Thus in the *Ku Chin T'u Shu* (an Encyclopedia published in Peking in 1726) repeated reference is made to plague outbreaks in Shansi Province which borders Inner Mongolia and in our times infected from the latter area. Although probably not all the "pestilences" recorded in the *Ku Chin T'u Shu* were true plague and though many occurred in more southern parts of Shansi Province, a list of the recorded outbreaks may with advantage be tabulated here:

A. D.	641	Great pestilence in Shansi Province.
	642	" " " " and Honan provinces.
	643	" " " " " " "
	644	" " " " " " "
	648	" " " " " " "
	1352	First month. Great pestilence in several districts of Shansi province; 900,000 persons estimated to have perished.
	1353	Twelfth month. Great pestilence in Ta-tung-fu, (in north of Shansi province); also in two districts of Kiangsi province.
	1358	Great pestilence in Fen-chow (southwest of Tai-yuan-fu), Shansi province. According to another source 200,000 persons perished.
	1414	Pestilence throughout Hang-chow, Hsiao-hsing, and Ning-po. In the third month in Chihli, Honan, Shansi, Hupeh.
	1504	Pestilence (Wen Yi') in several districts of Shansi province. (Bascome says that China was in that year "nearly depopulated by pestilence").
	1528	Spring. Great pestilence in T'aichow (in north of Shansi province).
	1543	Summer. Great pestilence in at Yu-tsze (Yutze near Tai-yuan-fu), Shansi province. Many 'hundreds' died.

- A. D. 1544 Great pestilence in Wen-shui (near Fen-chow), Shansi province; also in Chengchow, Honan province.
- 1560 Great pestilence in Shih-chow, Shansi province; "out of ten houses nine were empty".
- 1570 Great pestilence in Chieh-hsien (Chieh-chow S. W. of) Shansi province.
- 1579 Great pestilence in Hiao-yih (Hsiao-yi, S. W. of Taiyuanfu), Shansi province.
- 1580 Great pestilence in several districts of Shansi province.
- 1581 Great pestilence in Lu-an (in the southeast) and Ping-ting (in the east of) Shansi province. In Lu-an "the city gate opened by itself, and this was immediately followed by a pestilence, which spread in all directions".
- 1582 Great pestilence in Shantung, Chihli and Shansi provinces.
- 1585 Great pestilence ('Wen Yi') in Yuen-chu (Yuankühsien south of Shansi province). The mortality was so great that even relatives were unable to perform the funeral rites.
- 1588 Great pestilence in Hu-chow, Kia-hing, etc., Che-kiang provinces; also in Tseh Chow, (South Shansi province). Whole families perished; in other districts the wheat harvests could not be gathered.
- 1610 Great pestilence in Yang-chu, Shansi province. Distribution of medicines, etc. by the Governor.
- 1611 Great pestilence in Sui-chow, Shansi province.
- 1612 Great pestilence in Kia-hing, Chekiang province; also in Si-an, Shansi province.
- 1618 Great pestilence in An-yih, (near Yüncheng, southwest of Shansi province); also in Tsingchow, Hunan province, and in Kwei-yang (Kwei-chow province).
- 1633 Great pestilence in several districts of the Shansi province.
- 1635 Great pestilence in Lin-chin (Lin-hsien?) Shansi province.
- 1641 In the sixth moon. Pestilence ('Wen Yi') in Shantung; also pestilence in Chih Shan, Shansi province.
- 1643 Great pestilence in Mi-chih, Shansi province.
- 1644 Great pestilence in Lu-an, (in the southeast of) Shansi province. "Those attacked had hard lumps grow on the neck or arm, like clotted blood. Whole families perished. In some cases the victims vomited blood suddenly and expired."

Turning to our own times the following evidence for existence of plague in the central parts of Inner Mongolia is available:

i. According to Chinese reports which became known at the time of the 1917-18 Shansi epidemic, there is a disease known as 'winter sickness' which occurs periodically in the Ordos country and other portions of Inner Mongolia (1).

ii. From Russian sources it is stated that plague was prevalent in these districts in August, 1917 (1).

iii. Reliable records exist that pneumonic plague cases were seen in the vicinity of Patsebolong, Inner Mongolia, towards the end of November, 1917. This locality lies on the northern shore of the Yellow River, three days' journey on horseback distant from Paotu. Wu-Yuan city, lying north-east of Patsebolong, was also invaded early. From the Patsebolong district the infection spread eastwards, possibly carried by people who fled in panic from the plague area. It is certain that Paotu, an important commercial center, was invaded in December; on the 23rd of the same month the disease had reached Saratsi (Suiyuan district) and thence spread further eastwards. As is usually the case, the infection followed the routes of human traffic along the great road which runs north of the bend of the Yellow River through Patsebolong, Paotu, Saratsi to Kueihua, from where the roads branch off to Fengchen and Tatungfu. The main carriers of infection were wool-carters who were hauling great quantities of wool from Mongolia to the rail-head at Fengchen. This traffic was not swift, the early progress of the disease being estimated at 20-30 miles a day, but it was steady, several hundreds of carters passing a given point every day.

Though the epidemic spread mainly in an easterly direction it was also early directed to the south. Thus Sianor, situated across the Yellow River in the Ordos country, had already been invaded by the infection towards the middle of December.

A special article will be devoted to the 1917-18 epidemic which up to now has not been described comprehensively (See Appendix No. 1). We now turn to two areas situated in the west of Shansi proper, where suspicious outbreaks have occurred for several years, perhaps since 1912.

1. *Hsing Hsien.*

This mountainous county has little connection with the outside world except through one or two small Yellow River ports. Rapids in the big river make traffic difficult, and trails of pack-animals only proceed eastwards from the landing stages. Yet sheep and goat skins as well as wool come down from Mongolia, and Watson, missionary doctor in Shansi, (8) is inclined on the whole to connect the infection of the area with this traffic.

Statistical information kindly sent up by Mr. Chang Shu-Yi, official-in-charge of plague prevention in West Shansi, shows that as early as 1912 suspicious cases had occurred in 4 villages of the *hsien* (county); these were

Tsai chia hui	(蔡家會)
K'ang chia ping	(康家坪)
Liu-lin	(柳 林)
Yang-ping	(陽 坪)

Watson (8) claims that "the first cases of bubonic plague occurred in the southern part of Hsing Hsien in 1915 and 1916 before it spread over the border into Lin Hsien".

Mr. Chang's tables contain no information about these years but enumerate outbreaks during some of the later ones, thus:—

Year	Villages affected		No. of victims
1919	Pai chia san	(白家山)	?
1921	Ta p'ing yen	(大坪壩)	?
1922	Hsiao sun kou	(小孫溝)	?
1923	Ko ta shang	(圪塔上)	?
1924	Mu Chiang chun	(墓強村)	13
	Sha yuan chun	(沙元村)	13
	Wa yao ping	(瓦窯坪)	?
	Chang chia kou	(張家溝)	?
	Miao erh hui	(苗兒會)	52
1925	Hsueh chia t'a	(薛家壩)	17
	Kao hsien kou	(高顯溝)	7
	Chao lin p'o	(棗林坡)	?
	Sun chia chuang	(孫家莊)	7
	Chao chia kou	(趙家溝)	7
1926	Miao erh hui	(苗兒會)	45
	Chao lin p'o	(棗林坡)	17
	Mu t'ang wa	(墓堂壩)	3
	Yao t'ou	(窯頭)	4
	Han chia chi	(韓家集)	?
1927	Miao erh hui	(苗兒會)	?
	Wei chia chen	(魏家鎮)	30
	Chin chia wan	(金家灣)	7
	Chung yuan shang chun	(中原上村)	6
	Ko chen lun	(各針崙)	22
	Yao chia hui	(姚家會)	6
	Nan hui	(南會)	?

The 1924 outbreak evidently spread to the adjacent Lin Hsien, the total number of cases (all fatal) occurring from October to the beginning of November being computed at 790 (9). The bubonic type preponderated with only a few pneumonic cases.

This district seems to have been the starting point of the big 1928 epidemic as well. This will be described later on.

2. Lin Hsien.

This area lies to the south of Hsing Hsien and is of a similar mountainous character. It is a large county comprising in 1919 (10) 1,199 small villages, each averaging only 3 or 4 families. Like Hsing Hsien it has some connection with Inner Mongolia through the traffic along the Yellow River; moreover it is "only thirty miles from one of China's main trails bringing raw wool, hides, etc. from the west" (11).

The regular autumnal appearance of bubonic plague in villages previously attacked or in those situated nearby strongly suggests an aetiological rôle of rodents, especially rats. Conditions are certainly favorable for the latter: The houses built in or against the mountain sides offer ideal nesting places while ample food is available in the shape of enormous grain supplies kept by the villagers (11). Besides these domestic rodents a species of ground squirrel is said to occur (Watson, 1928).

A high mortality among rats seems to have been present during the 1919 outbreak. More definite evidence procured during the 1928 epidemic will be discussed soon.

Suspicious outbreaks (some confirmed) since 1917 may be tabulated as follows:

Year	Locality	No. cases	Remarks
1917 (autumn)	P'ei chia tsui (10 M. 裴家嘴 east of Yellow River)	Ca. 70	Few recoveries. App. bubonic.
1918 (autumn)	Liu chia shan (2-3 劉家山 miles from P'ei chia tsui)	„ 30	„
1918 (Dec.) 1919 (Jan.)	Wangchiap'ing and 9 王家坪 other villages (near above but far from districts affected in 1917-18 with pneu- monic pl.)	91	? pneumonic pl. (Bacter. exam. negative). Mortality 100%.
1919 (July-Oct.)	Hsi kou and 10 other 西溝 neighboring villages	Ca. 450 deaths	Bubonic (microsc. proved). Mortality ca. 96%.
1920	Sang shu miao and 4 桑樹峁 other villages	Ca. 100?	App. bubonic.
1921	P'o chun and 婆村 Lü chia kou 呂家溝	?	„
1922	Kao chia koling and 2 高家圪塄 other villages	?	„
1923	Chin chia miao and 2 靳家峁 other villages	?	„
1924	Ch'ao kou and 30 岔溝 other villages	597	Bubonic outbreak app. connected with that in the Hsing County.
1925	Li ko lao chu and 4 李圪老局 other villages	33	App. bubonic.
1926	T'u huo and 8 other 土壑 villages	? 171	„
1927	An chia chuang and 安家莊 14 other villages	? 164	„

3. *The 1928 outbreak.*

Our records of the 1928 epidemic are not yet complete, the official report of the plague detachment sent out by the Nanking Ministry of Health not having been published so far. From the Plague Bulletins of Dr. Watson, kindly placed at my disposal by the Health Ministry as well as other sources, it may be gathered that the outbreak, both in extent and the number of victims, was more severe than most of those observed previously in these areas. The infection, probably originating in Hsing Hsien, not only spread to Lin Hsien (according to Dr. Curran also into the Tsik'ou County in Shansi) but invaded Shensi Province to the west of the Yellow River, where five counties were affected. Moreover, independent centers were noted (a) in Hung Yuan Hsien (Shansi), 200 miles north-east of Lin Hsien and (b) in Paotow north of the Yellow River, i.e. in the area from where the 1917-18 epidemic started. No further details are at hand in regard to these two localities.

In Hsing Hsien 50 villages seem to have suffered, in Lin Hsien 38. Watson's estimate of over 1,000 deaths may be regarded as a conservative one.

Rat mortality was reported from several localities. Particularly significant is the information procured in regard to Miao-erh-hui (in Hsing Hsien), a village visited several times by the disease. When plague appeared there in 1928, the inhabitants locked up their houses and retired to caves in the mountains. When they returned to their houses after two months, they found several dead rats in the rooms. Had the villagers remained in their dwellings, these rodents would certainly have been disposed of by the numerous dogs and cats which serve everywhere as scavengers.* On account of their activity and because the people did not grasp the importance of submitting any dead rodents found for investigation, only few rats could be examined. Those seen evidently displayed typical signs of plague infection with glandular swellings, mottled liver, enlarged spleen and pleural effusions.

The character of the epidemic was prevalently bubonic. The mortality in this type was specially high in early and newly invaded villages (93% or more). In those which had been visited in previous years, recoveries were sometimes more frequent, the percentage of fatal cases being computed by Watson to be about 80%. Septicemic cases—with 100% mortality—were met with.

In at least 10 localities the disease assumed pneumonic features. Nevertheless Watson estimates the total number of primary pneumonic plague cases (all fatal) at less than 100 and ascribes this limitation of spread to the fact that early measures had been inaugurated in all these places. Escaping patients and contacts were not hospitably received when they reached neighboring settlements.

The methods taken in the 1928 outbreak were similar to those adopted in the 1917-18 epidemic. The afflicted families were confined to their compounds with proper instructions for isolating the patients as far as possible. Vaccine (supplied

* It is interesting to note that, while no unusual mortality was observed among the dogs, many of the cats, which are more susceptible to plague infection, succumbed (Watson).

by us and the National Epidemic Prevention Bureau at Peking) was administered whenever feasible. When the people wished to evacuate their villages to mountain caves they were encouraged to do so.

I propose to return to the problem of plague in Shansi in my final conclusions.

B. THE TUNGLIAO AREA

1. *General Description of Region.*

The Tungliao region is a vast expanse of more or less arable land, comprising former Mongolian territory. It is mainly flat country with stretches of sandy plains and low hills and has been opened up* for cultivation since the first year of the Republic (1911). Formerly inhabited by sparse nomadic tribes, this territory has shown an enormous influx of industrious Chinese from Shantung and Chihli Provinces amounting to over two millions during the past ten years. The advent of railways has both enhanced and quickened this immigration, but these have also brought with them attendant dangers in the form of bubonic plague from the endemic centers of Mongolia. Hence a short description of the main railway lines running through these parts deserves attention.

On the main South Manchurian trunk (S.M.R.) between Dairen and Changchun (438 miles) lies Ssupingkai, 72 miles south of Changchun. From this Japanese station of Ssupingkai there run the Chinese owned Ssupingkai-Tungliao and Ssupingkai-Taonan (named Ssu-Tao) Railways both passing through the important junction of Chengchiatun—the headquarters of the Taoyin or Superintendent of the District. From Taonan, another line passes northwards for 140 miles to Anangchi and Tsitsihar, thus meeting the Chinese Eastern Railway as it proceeds from Harbin to Siberia and Europe. To make things clearer the following table is attached:

				<i>Date of opening</i>
Ssupingkai to Chengchiatun.....	55 miles (88 kilom.)			December 1, 1917
Chengchiatun to Tungliao.....	71 „ (114 „)			November 5, 1920
Chengchiatun to Taonan	140 „ (224 „)			November 1, 1923
Taonan to Anangchi.....	140 „ (224 „)			July, 1925
Tungliao to Newchwang.....	240 „ (387 „)			October, 1927
Tungliao to Tahushan.....	156 „ (251 „)			October, 1927

Running southwards from Tungliao for 156 miles to meet the Peking-Mukden Railway is the Tungliao-Tahushan line, which is thus linked up with Mukden, Newchwang, Tientsin, Peking and the south.

The main produce from this district consists of beans, millet, maize, wheat, hemp, liquorice and hides. The country around offers splendid opportunities for

pasture, so before long the export of beef, butter and milk products may be expected. The River Liao and its branches water this region, but now and then, as in 1914, they overflow the banks resulting in disastrous floods. Wherever Mongols are met in the neighborhood of Chinese settlements, as at Tungliao, Chengchiatun, Chan Yu, Taonan, they have adopted the Chinese mode of living in mud-and-straw huts, sleeping on *k'angs*, and eating cabbage and millet as well as meat.

Of the towns, the following need mentioning:

Ssuningkai, partly Japanese and partly Chinese controlled. Population 50,000 including Japanese. Important railway works.

Pamiencheng (17 miles from above). Old fashioned city with well laid out streets. Before advent of railways was the main calling place of caravans between Mukden, Kirin and Heilungkiang.

Chengchiatun, situated on the right bank of the junction of the West Liao and Lao-ha Rivers. The River Liao is navigable from this point to Newchwang. Pop. 40,000. Seat of Taoyin and Magistrate. Opened to Chinese colonists in 1876. Important commercial center. Because of its strategic position, a quarantine station was established here for train passengers from the plague districts in 1928.

Chienchiatien, most affected plague village.

Out of normal population of 1,700, 349 were recorded as having died from plague in Sept.-Nov. 1928. Inhabitants have frequent intercourse with Mongols of neighborhood and live a rather primitive existence. Most of our plague studies of the 1928 epidemic were carried on here.

Tungliao. Terminus of railway on west. Pop. 25,000. Mostly immigrants from Shantung and Chihli. Agriculturists. Several Mongol villages border the north, River Liao intervening. Land quite fertile.

Sanlin. Actual town is 8 miles away from railway station. Some cases of plague were reported in this district.

Taipingchuan, railway station on the northern route connected with city of Chan Yu by motor bus. Over 90 cases of plague occurred here and probably arose from a separate focus in Mongolia.

Taonan, terminus in north of Ssu-Tao Railway, and connected with Tsitsihar by the Taonan-Anangchi Rly. Excellent dry bracing air, but land is not so fertile being somewhat alkaline. Pop. 24,000. Quite free from plague in 1928.

Our Expert staff has explored this region for both wild and domestic rodents, and collected nine species. These will be described in a following chapter.

2. *Suspicious outbreaks in the years 1924-27.*

Though a *prima facie* diagnosis of plague in the Tungliao region was made in the year 1927, and definite proof of its existence was not obtained till Sept. 1928, there is little doubt that it had been present in this area since 1924.

The report of Dr. Li Te-Chuan (see Appendix No. 2) shows that on June 20, 1924, the help of the Railway doctors was enlisted to combat an epidemic in an area 50 li (ca. 17 miles) distant from Tungliao City. Dr. Li on reaching Fuchiatun,

learned that a month ago many deaths had occurred at and near Hsiao-Nao-Pao. Since glandular swellings were said to have been present besides headache and sometimes diarrhoea, this outbreak seemed suspicious. Owing to the presence of many bandits in the country it was impossible to carry on further investigations.

On July 13, 1925, a disease characterised by the presence of swellings in the groins or axillary regions was again reported to have been present all around Hsiao-Nao-Pao. All affected were said to have succumbed within 1-2 days. When further enquiries were made at Tungliao, this information was not confirmed.

In the summer of 1926, when cholera was prevalent at Shanghai, an epidemic was said to rage at Nei-Mu-Ko-La, the patients suffering from headache and dying within 1-2 days. Since no official confirmation was forthcoming further action was not taken. Nei-Mu-ko-La lies to the north-east of Tungliao, being separated from it by the Liao River.

From the above scanty information it may be gathered that a plague-like disease was prevalent during the summers of 1924-26 in the districts north of Tungliao, but that the outbreaks, unlike those met with in 1927 and 1928, displayed little spreading power, and abated spontaneously.

Turning now to 1927, two facts are established:

a. That the outbreak first became manifest in the region of the Tangol Temple, situated north of Tungliao (and the Liao River) and being about 125 li (ca. 42 miles) distant from the city;

b. That it was in causal connection with a visit paid in August, 1928, by the Pantsan Lama to this region. When the priest, accompanied by a retinue of lamas and followers arrived, the people flocked together from near and far to worship, the daily gathering being estimated at 10,000 persons.

A Japanese Report (12) leaves open the question whether the infection was imported by pilgrims from their homes or whether the overcrowding of the region gave an impetus to the disease quietly smouldering at the spot. Discussing the different possibilities, the Japanese doctors mention one interesting aspect: The natives of Ta-erh-han region, not far from the Tangol Temple which had also been visited by the Lama, used to hunt a small wild rodent similar in size and habits to the tarabagan. The meat of these animals is partaken and their fur sold. Since there is some reason to consider the Ta-erh-han region as an endemic focus, these wild rodents might be suspected as carriers of the disease.

It is impossible at present to reach any conclusion in regard to this or similar theories. One point which in my opinion deserves special attention is that in 1927 as in 1928 the first victims seem to

have been Mongols, some of whom were lamas accompanying the High Priest.

News of the outbreak reached Ssupingkai about September 20, 1927. A trip made soon afterwards by Dr. Li to the affected region north of Tungliao disclosed nothing definite. Two Japanese doctors also visited the area and found a corpse outside the village Maliyintzu. *Post-mortem* revealed the presence of a pulmonary affection. Numerous plague like bacilli were found in smears, and later histological examination showed the presence of "acute hemorrhagic catarrh and exudative pneumonia". No positive cultures or successful animal experiments seem to have been obtained.

The exact number of victims of the 1927 epidemic is unknown. A table of cases, embodied in the Japanese Report (12) is here with reproduced:

Date	Locality	Deaths reported by villagers	Verified number of deaths
Late Aug.	Near Tangol Temple.	200	30
Sept-Oct.	Nemugol, Olebugol, Uranga and Consoben.	300	40
Late Sept.	Tsenchiawopo.	5	5
Early Oct.	Chien-Chia-Tien	—	5
"	Village 2 li east of Kailu. . .	—	8
"	Anarkamio	—	5
Early Nov.	Wanleko.	—	18
			111

The disease was prevalent not only to the north-east of Tungliao (reaching the area of the Hulagol Temple, 50 li north of Talin station) but also to the west of the city *en route* to Kailu, reaching a village 2 li east of the last-named town. The village Chien-Chia-Tien, though reported by the Japanese to have been affected in 1927, just escaped this fate according to Dr. Li's record. In general it may be said that

the infection was practically restricted to the districts north of the Liao River.

The principal measures devised against the outbreak were:

i. *At Tungliao:*

A meeting was convoked by the Magistrate on Sept. 24 which resolved upon the following measures:

1. Establishment of temporary headquarters at the district hospital. Sanitary inspection was carried out with the assistance of the police. Posters and leaflets.
2. Control of traffic between the city and surrounding settlements. No travellers allowed to cross the Liao River.
3. An office was established north of the river to observe the plague situation. A burying corps was organised and provision made for the burning or disinfection of all effects belonging the plague victims.

ii. *On the Railway line from Tungliao to Ssupingkai:*

1. Doctors were stationed at Tungliao, Chien-Chia-Tien, Chengchiatun (and Ssupingkai) to inspect incoming and outgoing passengers.
2. Third class travellers coming from the three first-mentioned stations were separately accommodated, their cars being locked at Ssupingkai pending inspection.
3. A sanitary car was attached to the trains to accommodate suspicious travellers.
4. Disinfecting apparatus and remedies were placed on each train.
5. Traffic to be suspended only in case of extreme emergency.

iii. *At Chengchiatun:*

An Anti-plague Committee was formed which in addition to carrying out the above traffic regulations provided for sanitary inspection of the city. An inspection-headquarter was established at the Pei-tzu Wharf, persons from the affected areas not being permitted to enter the city. The system of train inspection was enforced on Oct. 6.

iv. *At Ssupingkai:*

A temporary plague prevention office and a temporary laboratory were created by the Japanese. Premises were got ready to accommodate patients and contacts, if any. Besides examination of all passengers coming by rail from the west (which was soon entrusted to the medical staff of the Chinese Railway) sanitary inspection was carried out, special attention being paid to inns, eating houses and the like.

v. *At Mukden:*

The second class waiting room of the station was made the temporary headquarters of the plague prevention. Doctors stationed there made inspection of third class passengers coming from Ssupingkai.

vi. Similar precautions were taken at *Changchun* where inspection of north-bound travellers was carried out from the beginning of October by medical officers of the Chinese Eastern Railway.

The above measures were started rather late. While inspection of the railway traffic was perhaps carried out more often than would seem necessary, other phases of prophylactic work were evidently not undertaken with equal energy.

The value of the measures taken against the 1927 epidemic should not be overrated. It is difficult to imagine how the partial "cordon" at the Liao River could have stopped an outbreak comparable in its spreading powers to the pneumonic epidemics of North Manchuria. Fortunately the outbreaks in the Tungliao region seem to have spent their energy on the spot rather than proceeded onwards.

C. THE 1928 TUNGLIAO OUTBREAK

1. *First stages.*

It might seem strange after reading the foregoing pages that the possibility of a recrudescence of plague in the Tungliao region was not seriously anticipated. However, it should be remembered that the existence of suspicious cases during the years 1924-26 only became generally known after the presence of plague at Chien-Chia-Tien had been established on September 7, 1928 by Dr. Chun of our Service (see Appendix No. 4). There was little doubt that plague had occurred in the region north of the Liao River in 1927. The fact, however, that this outbreak was closely connected with the extraordinary event of the Pansan Lama's visit tended to allay the suspicion of endemicity in or near the affected districts, particularly as it seemed to assume later on a pneumonic nature. Even when plague was already prevalent in the regions north of Tungliao in 1928, it was by no means easy to establish its presence. An early trip undertaken by me in the middle of August elicited only vague information (see Appendix No. 3) while Japanese specialists from Dairen as late as Sept. 5 were not sure whether it was plague or cholera.

Regarding the earlier stages the following facts should be kept in mind:

a. That plague—mainly in a bubonic form—had been raging since the beginning of September at and near Chien-Chia-Tien and was also manifest in one or two separate foci.

b. That rats, said to have been numerous at Chien-Chia-Tien at the beginning of the outbreak, became fewer at its height. However, a number of animals captured or found dead by us showed ample evidence of plague infection.

On the other hand—as will be discussed soon—the available records suggest that the 1928 epidemic, starting within or near the localities affected in 1927, travelled southwards, infection being mainly carried by *human* agencies. And, inasmuch as we have experimental proof that human parasites did play a rôle in the outbreak, we must not underrate the importance of these reports. The question as to how the rats of Chien-Chia-Tien became infected is at present difficult to decide. So far as we could observe in the north and north-west of the plague area, rats were prevalent everywhere. But it remains to be seen to what extent this zone stretches side by side with infection among the rodents. A further complication is that the origin of plague outbreaks in those parts is probably connected with wild rather than domestic rodents—a surmise needing further confirmation, not so much in the Tungliao district as further inland in or near Mongolia proper.

We now pass on to an examination of the early records. The first news about the outbreak was published at the end of July in the South Manchurian papers and evidently based upon information from Chinese travellers who had arrived from the affected region. They spoke of suspicious cases near the capital of Ta-erh-han Principality, 60 li (20 miles) north of Tungliao, i.e. near the suspected endemic focus. A Japanese Report, published in the Weekly Report of the League of Nations, October 18 (13) mentions that early in July 33 plague deaths occurred at Chakan Talakao whence the disease spread to different villages northwards claiming 112 more victims. (The Chan-Yu district, invaded in the first half of August, may have received infection directly from this area.)

From available records it appears that in August the infection travelled along the prefectural highway running from Nei-mu-Ko-La

over Olibuko to Chien-Chia-Tien. Olibuko was possibly infected before the middle of August, this event being ascribed to the arrival of two travellers from Chenmaotoyintzu.

Chien-Chia-Tien is said by Dr. Li to have received infection from the village Kaochiaowopu (Chentaowopu) 20 li or 7 miles to the northwest. A woman with two children arrived from the last-mentioned settlement towards the end of August; both the latter died in the eastern part of Chien-Chia-Tien while the woman succumbed on the way back. Soon afterwards (August 27) the first case in a Chinese inhabitant was noted. Thus far Dr. Li's version. Possibly the infection of Chien-Chia-Tien had occurred earlier, as I was informed that a Mongol traveller, arriving from Kaochiaowopu during the middle of August and occupying a room in the local inn, died within two days. According to this source the first Chinese case appeared on August 21.

Whichever date be correct, there is little doubt that the village inn, a large but poorly constructed mud-house in the easternmost part of Chien-Chia-Tien, was even then a hotbed of infection. If it be assumed that infection of the local rats occurred early in the 1928 outbreak through infected fleas brought by travellers, this house would form an ideal *milieu* for such a transition of infection. When first seen by us (after the 13 permanent inmates including the owner had died) it was in a fearful condition. Mats, bedding, clothes, pails, basins, kettles and rubbish were thrown about anyhow. The unswept matting of the *k'angs* (sleeping platforms) was disarranged. Packages and bundles of clothing were stored at the angles of the roof beams. Numerous rat holes were noted in the walls and the adjoining mudfloor. Fleas jumped about merrily eager to attack any freshcomer.

2. *The epidemic at Chien-Chia-Tien (September-November, 1928).*

a. *Description of the village.*

Chien-Chia-Tien is a small village with 1,700 inhabitants situated $3/4$ of a mile to the north of Chien-Chia-Tien station (14.6 E.M. east of Tungliao and 111.4 M. west of Ssuping kai. It was formerly waste Mongolian land but had been cultivated within recent years by the exertions of General Chang Tso-lin for the growth of kaoliang, wheat, maize, beans and hemp. The village is divided into two main parts: (a) *westend*, containing brick- and shop houses; (b) *eastend* comprising

mud- and straw huts for the poor. Among the latter is an inn which after 13 persons (including the proprietor) had died was utilised by us after proper disinfection as a temporary hospital.

The eastern quarter is markedly rat-ridden, both walls and mudfloors showing large and small apertures for the habitation of these domestic rodents. The roofs are largely constructed of six-inch thick bundles of kaoliang stalks, supported on rough beams of timber. Sometimes a thin layer of paper is laid across the top to form a ceiling, thus allowing free play to the unseen rats. For sleeping purposes *k'angs* (heatable platforms) are made of straw- and mud bricks with hollow flues for the circulation of warm air. Probably rats can also communicate with these from the walls and enable fleas to attack human hosts. Windows consist mainly of movable wooden frames over which opaque pieces of rice paper are pasted. Outside these frames, blinds made of kaoliang stalks are suspended from the eaves and are pulled up in the daytime.

The occupants of these primitive houses are most untidy leaving their clothes, bundles, shoes, hats in every available space, including the corners between the beams and roofs. Cooking, eating and storage of food are undertaken within the same premises, thus permitting of easy access to rats and consequent infection.

Connected with a number of houses is a common courtyard where donkeys, horses, pigs, cows and dogs have their abode, and these vie with their human hosts in untidiness. It is not strange therefore that a plague epidemic finds the inhabitants of such a village unprepared and helpless. In the western quarter occupied by better-built houses and a more intelligent population there were much fewer fatalities from the epidemic, the proportion being 1:9. The roads are not paved and numerous rat holes exist at the corners.

b. *General description of the outbreak.*

No exact figures are available for the first two or three weeks after the invasion of Chien-Chia-Tien. So far as could be established afterwards, the deaths occurring up to September 1 may be computed at 45, while a total of 37 deaths is known to have taken place between September 1 and September 8. After that fairly reliable statistics are obtainable (see Appendix No. 5). The total known cases at Chien-Chia-Tien and vicinity may be computed at 352, thus :

Deaths	in August (approx.)	45	
"	September 1-8	37	
"	September 9-November 9	258	(of them 51 in vicinity)
Total deaths		340	
Known recoveries		12	
Approximate total cases		352	

Though this total is fairly correct (the population of the village before the outbreak being 1,700), we refrain to figure out the percentage morbidity because soon after the disease appeared serious at Chien-Chia-Tien an exodus began. On September 16, when I took actual control of the situation, the inhabitants were estimated at 1,100 only. The figures collected by our staff between October 6-8 are as follows:

Number of houses	154	Infected	34
Inhabitants male	577		
female	272		
total	849	Died	91
		Left	758

These figures are incomplete because:

- i. Owing to the resistance of some families not all houses could be entered by our staff;
- ii. Empty houses were found about which exact data could not be obtained.

Thus the percentage of fatal cases to be computed from them (10.7) appears too low and it seems that the mortality came nearer to 20 than to 10% (that is one-fifth of the normal population).

A second set of statistics collected by our Disinfecting staff between October 2-8 speaks of 108 deaths in 36 infected houses. In seven of these all the inmates had died off. The percentage of deaths in the others is as follows:

<i>Percentage of deaths</i>	<i>No. of houses</i>
(100)	(7)
80	2
70	3
60	5
50	2
40	3
30	4
20	5
10	3
0-9	2
	<hr/> 36

It is significant that the two biggest compounds had comparatively the smallest number of deaths (1 in 32 and 1 in 28). These compounds consisted of comparatively rat-proof brick buildings which were less crowded. Thus it was easy for the occupants to give a wide berth to

the solitary patients. In the miserable hovels of the East-end conditions were much worse.

C. Measures taken at Chien-Chia-Tien.

Definite news about the presence of a fatal epidemic at Chien-Chia-Tien reached Ssupingkai on September 1. The Railway authorities then took prompt action and suspended on the same day the entire service (both passenger and freight) from and to Chien-Chia-Tien and some adjacent stations; trains only stopped there for emergencies. An attempt to quarantine the village proved futile; in fact it is known that during the panicky interval of September 1-14 many villagers boarded trains at adjoining stations and escaped. The Railway authorities, willing to do their utmost, stopped the whole traffic on the Tungliao-Ssupingkai line on September 14, while on September 15 both passenger and goods traffic was suspended on the Tungliao-Tahushan section. A squad of special mounted police was sent to Chien-Chia-Tien on September 13, the former head of Police was dismissed next day, his successor assuming office on September 15.

Drastic as these steps were, they were directed solely against a prevention of spread from Chien-Chia-Tien, while the unfortunate inhabitants were over a fortnight left to their fate. The horrors of this time can be well imagined. When I first visited the village on Sept. 16, I learnt that the sick were left unattended and begged in vain for relief. The dead were carted out in the dead of the night and often remained unburied. There was soon a shortage of coffins, some already used ones being sold again after the corpses had been wrapped in matting and carted secretly to the open fields or usual burial ground 2-3 miles away. The epidemic became firmly entrenched, 106 deaths having been registered from September 1-16. Thus, when taking actual control of the epidemic on Sept. 16, I was confronted by an awkward situation.

Cases occurred mainly in the hovels of the East-end, which were both insanitary and rat-ridden. The villagers were suspicious and backward in modern ideas. They did not welcome the white-robed doctors and would not report any sick in their homes willingly. In order to propitiate the pest devils, they predated the New Year by pasting red seals and inscriptions over their doors as well as suspended

monkey-shaped dolls made of blue cloth from the roofs so as to render their bodies immune. Our best hope lay in their acquiescence in our measures rather than intelligent co-operation. Even the few educated leaders had only vague ideas about the causes of plague, believing it due partly to poisonous emissions from the ground and partly to contaminated water.

These conditions naturally restricted our program to a few essential measures :

- i. Educational campaign through printed leaflets and lectures;
- ii. Isolation of patients in the temporary plague hospital;
- iii. Evacuation of the contacts;
- iv. Disinfection of infected houses (with sulphur);
- v. Systematic vaccination of the population;
- vi. Cremation of the dead.

For evacuation purposes a newly built military camp situated $1\frac{1}{2}$ miles from Chien-Chia-Tien, consisting of fine brick barracks was put at our disposal by the high military authorities of Fengtien. This would have been large enough to accommodate the whole population, but complete evacuation was found impracticable owing to the unwillingness of the population and insufficient support from the police. In fact we found that even in questions like house-to-house inspection, hospitalisation of patients and isolation of contacts, the police would only co-operate so long as matters went smoothly. Whenever resistance was encountered (which happened often), our sanitary staff were largely left to their own devices, e.g. appeal, persuasion, etc. The higher authorities would have been willing to dispatch a military detachment to our help but ripe experience of past campaigns desisted us from taking this extreme step. We preferred to win the good-will and confidence of the inhabitants, though so many seemed fatalistic in the presence of death. It was therefore resolved to send the willing contacts to the camp and to confine the unwilling ones to their own compounds under proper supervision. Pressure was exerted when the abodes were unsafe for properly housing the contacts. The following table shows the number of persons isolated in the camp and in their compounds respectively:

Sex and Age	Isolated in camp	Isolated in own homes	Total
Adult males.	87	121	208
Adult females... ..	40	123	163
Males under 12 yrs... ..	26	84	110
Females under 12 yrs	29	112	141
Grand Totals :	182*	440	622

No. receiving anti-plague vaccine. 603

In spite of these compromises, the results obtained exceeded our expectations, for within less than a fortnight from the time when proper measures were instituted, the mortality rate had fallen from 20 to 2 or less. For this success, the greatest credit is due to Asst. Med. Officer Liu Tso-hsin, who had been trained at our Harbin Hospital and had been in charge of a Pneumonic Plague Ward during the epidemic of 1921.

The population soon realised that the critical stage had passed. The shops which had been closed since early September, gradually reopened their doors. On October 13 they held a solemn procession, over 300 persons parading the streets from 8 o'clock in the morning till 2 in the afternoon, wearing banners and sounding drums and flutes. At the head was a woman of forty with hair all loose and clad in a red dress. Probably she was in a *trance*. Sheep and pigs were offered to the unseen gods for having driven the pest away. The Police Chief was made to "kowtow". Our white-robed doctors who had borne the brunt of the battle were quite neglected!

Some misgivings were entertained that this gathering of so many excited persons might give a new impetus to the infection and incite the people to resistance against our anti-plague measures. Fortunately no disaster followed. Cases became soon sporadic, the last death in the vicinity being noted on November 9.

*Only one old woman was found sick when arriving in the camp on Sept. 29 (with buboes in groins). She was sent to hospital where she recovered.

- d. *Measures taken against a spread of infection from Chien-Chia-Tien by rail.*
i. *Chinese Govt. Lines.*

Allusion has been made already to the inauguration of restrictive measures on both the Ssupingkai-Tungliao and the Tungliao-Tahushan Railways, where the traffic was entirely suspended on September 14 and 15 respectively.

The traffic on the Tungliao-Ssupingkai section was reopened on September 27, only the actually infected stations remaining closed. This step was taken because prophylactic measures had been taken in three ways (see Appendix No. 6):

1. A doctor or assistant was placed at every station, important places having senior medical officers.
2. Every passenger train was accompanied by a medical officer (this measure being taken also on the Taonan-Ssupingkai and later on the Tungliao-Tahushan lines).
3. Provision was made for a quarantine of five days at Chengchiatun for all III class passengers from the west. In the beginning ten heated III class cars were used; later on these were replaced by a series of specially adapted quarters within a closed compound near the station with accommodation for 150-200 persons. These quarters had been kindly repaired and lent by the South Manchurian Railway authorities.*

An understanding reached with the South Manchurian Railway authorities on September 19 (Appendix No. 6) for travellers after detention at Chengchiatun to pass freely to the South Manchurian Railway trains.

The Tungliao-Tahushan line remained closed until October 13 because the plan submitted early by Dr. Phillips (Newchwang) and endorsed by me to establish a quarantine station there was not realised. When traffic was resumed, medical inspection of passengers from the north was carried out. The same precaution was started from September 13 at Newchwang, where we have a permanent Quarantine Hospital of our own.

While the epidemic showed some tendency to spread from Chien-Chia-Tien along the railway eastwards, not a single case was reported on the Tungliao-Tahushan section. Nevertheless it would be unwise to neglect this line should future outbreaks occur.

*Altogether 531 travellers passed through this quarantine including some Russians and Koreans. Not one developed sickness during the whole period. Pulse and temperatures were taken morning and evening beside general medical inspection.

ii. *South Manchurian Railway.*

As can be seen from the agreement reached with the S. M. Rly. authorities on September 19 (Appendix No. 6), ample precautions were taken by the Japanese not only at Ssupingkai but along the whole line from Mukden to Changchun. In Mukden energetic measures were early started by the Chinese authorities. At a meeting called by Mayor Lin Teh-hsin on September 14, it was resolved to organise a Plague Prevention Committee. Funds amounting to \$100,000 were provided for the work and an observation point was established at Huangkutun (Mukden).

No true plague case was detected on the S. M. Rly. line or anywhere in adjacent territory. Some alarm was caused in the afternoon of October 4 when a suspicious case was detrained at Mukden station. The traveller in question, a Chinese aet. 21, had come from Kaitun on the Ssupingkai-Taonan line and had developed fever while travelling in the Japanese train. He was brought to the detention house where it was established the case was only one of TB.

iii. *Changchun-Kirin line.*

Here medical inspection of passengers was started on Sept. 14.

iv. *Chinese Eastern Railway.*

Though patients could reach the C. E. Rly. both at Changchun (from the S. M. Rly.) and at Tsitsihar (via the Taonan-Tsitsihar line), the former point could scarcely be endangered in view of the ample precautions already taken in the south. Therefore it was resolved at a meeting held on September 26 at Harbin to establish an observation point Tsitsihar only.

v. *Discontinuation of above measures.*

The measures outlined above were in general stopped on Oct. 30, the suspension of the traffic at Chien-Chia-Tien together with adequate precautions on the Tungliao-Chengchiatun branch remaining in force until November 15, when the outbreak at Chien-Chia-Tien had entirely subsided.

3. *Outbreaks in other localities along the Tungliao-Ssupingkai Rly.*

a. *Tungliao (14.6 E.M. west of Chien-Chia-Tien).*

Our information about early cases in this city is not complete. When I first visited the place on August 20, I was told by Dr. Cheng,

an experienced local practitioner, that four patients had successively consulted him early in August, all hailing from one compound in a neighboring village; they said that three others living with them had died of high fever and unconsciousness, and one had a bubo in the right groin.

The four patients seen by Dr. Cheng were as follows :

No.	Sex	Age	Symptoms	Death occurring after
1	F.	46	Fever, cough, diarrhoea and vomiting... ..	2 days.
2	M.	40	Fever, headache and delirium (no cough).	1 day.
3	F.	24	Fever and vomiting.. ...	?
4	M.	52	Fever (102°), rigor, backache.	Died suddenly.

It can be seen that the symptoms of these patients are somewhat vague. Because they were in etiological connection not only with one another but with the three previous cases (including one with bubo), there is good reason to suspect that these suffered from plague.

It was fortunate that no spread of infection took place at Tung-liao from these early victims. The city was actually infected early in September through a patient escaping from Chien-Chia-Tien, the first authentic case (a boy, aet. 3, falling sick on Sept. 10) being probably associated with this. Further cases occurred both in Tungliao and some surrounding villages (including Maliyintzu, where 8 deaths were registered between October 7 and 9); the total number is estimated at 40. In Tungliao itself we counted 14 well established deaths. The last two deserve special discussion as they concern two members of our Chien-Chia-Tien staff.

i. Servant Huang, aet. 36. Formerly engaged to sweep the laboratory but forbidden to enter when experimental work was started on September 26. He had been once vaccinated on September 29 and lived with the majority of the staff in unused Railway Goods Office, one isolated wing accommodating the laboratory. As ascertained afterwards Huang was an opium smoker and used to visit the village secretly in order to indulge in this habit. Evidently he became infected during one of these excursions, as it is difficult to see how this could have

occurred while on service, since his duties consisted of keeping the living rooms clean and carrying water. Huang fell ill on October 7, complaining of fever, headache and 12 days' constipation. Though his eyes were somewhat blood-shot, this anamnesis and the comparative slowness and good quality of the pulse allayed suspicion. He was sent to the Tungliao Rly. Hospital on October 8, when an enema was given with good result. Temperature fell to 37° and remained so for 3 days. His blood was examined on October 10 at 3 p.m. and *B. pestis* were found. Died at 9 a.m. on October 11. No post-mortem was made.

ii. Coolie Ting Hui San, aet. 21, had been employed for 10 days with the disinfection squad. Ran away with 7 others about October 5, having probably absconded with valuables belonging to plague victims. Died suddenly on October 11 at Tungliao. Autopsy by Dr. Li established a positive diagnosis of plague.

Anti-plague measures at Tungliao were started early. At a meeting convoked by Magistrate Chi on September 7 it was decided to form an Anti-plague Committee of local gentry and doctors. An isolation hospital was installed where ten patients were cared for at various times. Dr. Yuan from Mukden and Dr. Cheng were jointly in charge.

b. *Talin (15.5 E.M. east of Chien-Chia-Tien).*

Talin, a village of 4,000 inhabitants north of the railway track was repeatedly invaded. The first suspicious case was in a Chinese working in a foundry who died on September 3. The next victim was a Mongol, over 40 years old, who arrived from Chien-Chia-Tien and died 5 hours afterwards in the village. Further deaths occurred in 7 families, totalling 27 up to October 3. Some of these are not confirmed.

The measures taken at Talin included house to house inspection by our M. O. and Police, segregation of sick when found, vaccination of contacts and cremation of dead. One cook employed in a restaurant escaped by foot to Chengchiatun where he died (Vide). Two corpses were found hidden inside a *k'ang*.

c. *Chengchiatun (56 E.M. east of Chien-Chia-Tien).*

The steps taken in regard to the railway traffic have already been described in a foregoing paragraph. Only two plague cases were noted. The first was registered on September 25 and concerned a Chinese with a bubo in the groin, who was probably a refugee from Chien-Chia-Tien. A second case developed in an employee of a restaurant at Talin who escaped to Chengchiatun and died there on October 3. No further spread took place.

d. *Pamiencheng (93 E.M. east from Chien-Chia-Tien).*

Pamiencheng is the last big station before Ssupingkai (17.5 E.M.). A Chinese boy, aet. 15, arrived on the afternoon of Sept. 25 with the train from the west and lodged with his relative—an employee in a big granary—among 40 others. About midnight he suddenly coughed up blood and died soon afterwards. Our Dr. Huang who was sent from Ssupingkai ascertained the presence of a bubo in the groin. Examination of material taken after death also proved the diagnosis of plague. The patient had come from Chien-Chia-Tien, having travelled on foot to Chengchiatun junction and then boarded the train. The whole compound where this death occurred was isolated by us, the room was sulphurised and all inmates were at once vaccinated. Five immediate contacts (two with flushed faces) showed slight fever (one up to 38.7°). With proper laxatives their temperatures went down and all remained healthy.

The local gentry and merchants were unwilling to start anti-plague measures, though a committee was formed to undertake the following steps:

- i. Establish temporary headquarters at the station master's office and inspect passengers;
- ii. Provide an isolation house with a capacity of 10 beds;
- iii. Inspect inns and eating-houses, all suspects to be sent immediately to the isolation house;
- iv. Notify any sudden illness or death.

4. *Outbreaks near the Chengchiatun—Taonan Railway.*

The further one travels northwards from Chengchiatun, the more changes one notices in the character of the country. The soil though still yielding fair crops, especially of kaoliang, is not so fertile as in the Tungliao District. And, since the population is less dense than in the South, vast stretches of land are still uncultivated, being covered with grass and bramble-like bushes and affording ample pasturage for cattle, horses, etc. The settlements are generally smaller and further apart than near Tungliao. Mongol villages are frequently met with, often quite near from the Railway. These inhabitants have mostly adopted Chinese dress and habits. The houses of Mongols who live among Chinese—as far westwards we came we have met with settled-down Mongols only—differ little from those of the Chinese settlers. In the interior a few differences are noted:

a. Though *k'angs* similar in outer appearance are used for sleeping purposes, they are not heatable. The rooms are warmed with the aid of open fires, large iron pans being placed on earthen pedestals; here dried bramble-bushes, kaoliang stalks, etc. (rarely dung) are burnt.

b. Reed mats (*hsi*) as used by the Chinese for covering their *k'angs* are usually absent in Mongol homes; instead they use a kind of felt made of wool and identical with the *kochma* which plays according to Nikanoroff (14) some rôle in the epidemiology of plague in South-East Russia.

The houses and huts of the Mongols, as of the Chinese, are insanitary in every respect. Rat-holes are found in the out-buildings, both large and small settlements, observed by us in the west and north, being infested with domestic rodents. Wild rodents (both *sisels* and *jerboas*) are said to exist in limited numbers at some distance from human habitations. Thus far we have had no opportunity to study them.

We may now pass to a description of the two plague outbreaks occurring in this area:

i. *Sanlin*.

Sanlin is a small station, situated 43 miles north of Chengchia-tun junction. Seven miles distant from it lies the village Hauchinko-lintun, where practically all the 23 authentic plague cases in 8 families registered between September 6 and 26 occurred. All the patients (one of whom recovered) were Mongols. A further interesting feature of this localised outbreak is that no connection with the Chien-Chia-Tien area could be established, infection having in all probability started independently from the regions north of Tungliao.

Several cases had already been reported when our Medical Officers arrived. The measures taken by us afterwards closely followed these at Talin and other places. We found the Mongols as superstitious as the Chinese immigrants, not submitting quietly to modern preventive measures. A considerable proportion of the victims were women and children.

ii. *Chan-Yu*.

Chan-Yu City, the capital of a prefecture, lies 25 miles to the north-west of Tai Ping Chuan station (69 miles north of Chengchia-tun), with which it is connected by a motor-bus line. While the city itself remained free from plague, outbreaks were noted in five neighboring localities, thus:

Locality	Date onset	Date end	No. cases	Mongol victims
Katawantung	August 11	Sept. 14	14	13
W. Chakanalapuko.	Sept. 1	" 16	15	12
E. Chakanalapuko.	" 19	Oct. 3	7	6
Huasin Olatung.	" 8	Sept. 25	23*	22
Tunghua On ton.	" 23	" 25	3	3
Five localities... ..	August 11	Oct. 3	62	56 (90.3%)

*One recovered.

The Magistrate of Chan-Yu City, a college graduate and an observant man expressed the opinion* that infection in his district had been imported from Chien-Chia-Tien, saying that a coolie refugee with things stolen from the dead reached the southwest section of his district where he died, the infection then spreading to others. Without denying the possibility of such importation we must point out that the outbreak at Katawantung (see foregoing table) had started on August 11 already, before any plague was reported at Chien-Chia-Tien and coolies were employed for anti-plague work. Hence there is little doubt that here, as well as at Sanlin, the disease was directly imported from the west, the sparseness of the population and the great distances between the individual settlements delaying its spread.

The rural character of the Chan-Yu outbreak necessitated a special organisation. An anti-plague bureau was established in the city where our medical officer was stationed. Isolation compounds were established here as well as at 4 other points. In the four worst infected villages local committees were formed, the members receiving a small remuneration for their labors. In each place also a specially-paid police squad was stationed. Our Medical Officer visited the localities as often as possible by motor-car or on horse-back to supervise the work of the local organs. Thanks largely to the progressive views of the Magistrate this organization worked smoothly.

*See Appendix No. 8.

iii. *Taonan.*

This important center (139.5 miles from Chengchiatun) remained entirely free from plague. Two suspicious deaths proved not to be plague occurred on September 19-20. Officials and gentry co-operated willingly with us. In view of its strategic position, one of our Senior doctors Shih was on duty from September 26 to October 2, to start the work. Later on Doctor Cheng of the railway service was left in charge, his duties being mainly supervision of the passengers *en route*.

5. *Suspicious outbreaks in Kirin Province in December, 1928.*

Our records would not be complete without the mention of two outbreaks occurring in December 1928 in Kirin Province. Though their character could not be confirmed by proper methods they are on the whole suspicious for plague and probably originated from the vast Mongolian territory in the west which we have good reason to consider as an endemic center and the starting point of the epidemics in Tung-liao and adjacent regions.

a. *Nungan*

Early in December vague news reached us about the occurrence of plague in South Manchuria. On December 14 it was definitely stated that about 30 fatal cases resembling pneumonic plague had occurred in the Nungan District.

Nungan City is situated in the south-west of Kirin Province near the Itung River, about 120 li (40 E.M.) north of Changchun, the nearest point of the Changchun-Harbin Railway line in the east being distant about 70 li (ca. 23 miles). This city had suffered in the 1910-11 epidemic (when almost 500 deaths were reported) but had seemed free ever since.

Telegraphic enquiries sent to the Magistrate at Nungan elicited the following:

"23 suspicious cases, all fatal and characterised by blood-spitting and headache, occurred between November 18 and December 8, 1928. Of these 21 were recorded in the special 'Manchu Area' (not under the Magistrate's control) and only 2 in his own district. For two weeks no new case."

Further enquiries state that the early cases started from neighboring Mongolian territory. A letter received from the Nungan Magistrate (see Appendix No. 9) says that the first victims were a buddhist monk and his two pupils, who had visited the locality Chienchi, ca. 30 miles away from the 4th and 5th areas of the Nungan district, where they stayed at an inn for one night. Next morning

the monk and one of his pupils as well as the owner of the inn were found dead. The other pupil tried to escape but succumbed on his way to the south. Since the other inmates of the inn also died it was not possible to ascertain exactly from where the travellers had come.

If this story be true it would suggest food-poisoning rather than an infectious disease on account of the short contact the inn-keeper had with his guests. Probably, the facts were otherwise. It is stated that the subsequent victims all had cough with bloody expectoration, succumbing after an illness from 6-9 hours to 1-2 days. Moreover, the Magistrate states that Chienchi (the residence of a Mongol prince) has suffered from a similar epidemic some years ago. The history of the two cases in Nungan area proper is as follows :

i. On December 3 a young man returned to his home at Kaochiatien (in the 5th area of the Nungan District) from the Chienan area. During the night he complained of headache and blood-spitting and died next morning, having been ill for two days altogether.

ii. A young man returning from Chienchi to Halahaichintze (in the 4th area of the District) spat blood and died suddenly.

Adequate measures were undertaken in both instances. The victims were buried in coffins containing lime, their effects were burned and the people around them isolated. The provisional plague prevention bureau at Nungan city quarantined the area against the adjacent Mongolian territory and sent Medical Officers and sanitary coolies to the Mongolian frontier to do such preventive work as burning corpses, disinfecting houses, etc. Perhaps a powerful factor in the limitation of spread was the sparseness of population in the affected districts.

b. *Fu Yü*

On December 22, private information reached us about a suspicious outbreak in a village near Fu Yü or Petune (called Bodune by the Russians). A local Danish missionary wrote that in one family alone 17 persons succumbed to the disease.

Fu Yü, an important trading center with almost 60,000 inhabitants, lies to the south-west of Harbin (320 li or 107 E.M.) on the northern shore of the Sungari River. It is connected by a motor-bus-line with Sanchacho Station of the Changchun-Harbin line (80 miles). Cart routes also connect the place with Harbin directly and with Anta and other stations of the western portion of the Ch. E. Rly. The place was attacked by the 1910-11 epidemic, the exact number of victims then claimed being unknown. It is comparatively near Mongolian settlements on the South of the Sungari River; a prince resides 90 li away.

We at once sent one of our Medical Officers from Harbin to Fu Yü. He returned on December 28 and reported that an outbreak had taken place early in December at the village Cha Chia Yuantze (2 li north-east of Fu Yü). This village covers a wide area with scattered abodes totalling 200.

Though our Medical Officer was told of 12 cases in Fu Yü he established through house-to-house inspection that only 7 fatal cases (in 3 families) had taken place altogether in the village; one family had lost 5 out of 8 members. The patients were said to have suffered from headache and to have died after 2 days' illness. There was no cough and only one showed a little blood on his lips when dying. During the three succeeding weeks no new cases developed and our Medical Officer believed the epidemic had died out. The temporary quarantine bureau established in the Fu Yü Police Office was soon closed.

A previous rumour had connected this outbreak with that at Nungan (180 li or 60 miles distant) but our Medical Officer could not obtain any confirmation. This outbreak is therefore still more doubtful than the Nungan one.

6. *Concluding remarks.*

Summarising, the number of fairly well established cases occurring in the Tungliao region in 1928 may be estimated as follows:

Chien-Chia-Tien	352
Tungliao and vicinity	40
Talin	27
Chengchiatun	2
Pamiencheng	1
Sanlin	23
Chan-Yu	62
North and elsewhere	90

597 or roughly 600.

In many respects the successful termination of the Tungliao epidemic within a comparatively short time and its low budget was rendered possible:

Firstly, by the most helpful attitude of Marshal Chang Hsueh Liang and Governor Chai of Fengtien who provided the \$31,000 requested by me on September 17 within the record time of 24 hours.

Secondly, by the loyal co-operation of the Ssu-Tao Railway authorities who provided quarters, cars and traffic facilities for our purpose.

Thirdly, by the rapidity with which instructions from headquarters at Ssuningkai could be established by the use of long distance telephones placed at our disposal by the Railway.

Fourthly, by the fine team work of our medical and lay staff none of whom questioned the authority of the Head on urgent as well as ordinary occasions.

Dr. Kanai and his assistants of the South Manchurian Railway assisted us with frequent advice, and lent some unused buildings near the station of Chengchiatun for quarantine purposes.

II. CLINICAL AND LABORATORY OBSERVATIONS DURING THE 1928 TUNGLIAO OUTBREAK

WU LIEN-TEH AND R. POLLITZER

A. Introduction.

B. Clinical Observations.

1. Sex incidence.
2. Age incidence.
3. Duration of illness.
4. Type incidence.
5. Symptomatology.
6. Recovering cases.

C. Laboratory Activities.

1. Vaccine preparation.
2. Establishment of Field Laboratory at Chien-Chia-Tien.
3. Human post-mortems.
4. Observations upon rat plague.
5. Experiments with human parasites.
6. Conclusions.

A. INTRODUCTION

The Tungliao plague was the first bubonic epidemic to be studied at close quarters by us in Manchuria. With an experience of three extensive pneumonic epidemics as a background it was natural that we should use every opportunity to watch carefully for any possible connection between the two types. For this purpose we made careful preparations from the beginning for laboratory observations and experiments as well as routine measures of plague prevention and treatment. In the plague hospitals we distributed printed sheets with diagrams denoting the location of buboes so as to facilitate accurate registration by simply marking off the affected parts. As far as possible standardisation of methods including case reporting was adopted, the object being to save unnecessary writing which on urgent occasions and in different individuals might possess different meanings.

We had a staff of 18 Medical Officers and 19 assistants, many of whom, however, had seen little or no plague before. The more experienced ones were concentrated at Chien-Chia-Tien where 352 cases occurred out of a total of 693. Our expert laboratory staff were also housed there in an unused goods registration office, their sleeping quarters being placed next door to the laboratory. It is to be expected therefore that the most accurate observations (including clinical) were made at Chien-Chia-Tien village. The limited number of cases recorded in our statistics from this area are from actual observations made in the hospital and in their homes by trained Medical Officers. At Tungliao and Sanlin the statistics were also based upon personal observations. At Chan-Yu, on the other hand, our Medical Officer had to rely mainly upon the data supplied by the head-men and relatives of the sick Mongols, not always accurate in details.

In order to study the incidence of pneumonic complications in bubonic cases we performed as many *post-mortems* as were available. Here again, to facilitate our working plan as well as to allay the suspicions of the populace, we carried the dead from the hospital to our cremation pit situated one fourth of a mile away. Autopsies were made in the open field after which the remains were dragged into the burning pit a few feet off. For all purposes as few non-medical persons as possible were present. Much trouble was caused by the fierce village dogs which constantly hovered around us and readily devoured human cadavers without compunction if not driven away.

B. CLINICAL OBSERVATIONS

1. *Sex incidence.*

It may be recollected that the two big epidemics in Harbin in 1910-11 and 1920-21 affected mostly a floating population with a comparatively small incidence of cases among women. Since that time, with the development of quick transportation, immigrants from Shantung and Chihli have brought their families with them to settle down even in isolated districts. At Chien-Chia-Tien quite a number of women and children were to be found, and plague therefore claimed a comparatively higher mortality among them than during the Harbin epidemics.

The following figures may be quoted :

	Chien-Chia-Tien		Tungliao		Sanlin		Chan-Yu		Total	
	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent
Males	75	72.1	11	91.7	16	69.6	44	71.0	146	72.6
Females	29	27.9	1	8.3	7	30.4	18	29.0	55	27.4
Total	104		12		23		62		201	

Comparing these with data available for the distribution of sexes in Chien-Chia-Tien, we find:

	(a) Counted in Oct.		(b) Isolated in camp		(c) Isolated in homes		(d) Plague incidence	
	No.	per cent	No.	per cent	No.	per cent	No.	per cent
Males	577	68.0	113	62.1	205	46.6	75	72.1
Females	272	32.0	69	37.9	235	53.4	29	27.9

These figures show:

i. Although the above statistics are incomplete, they may be regarded as fairly representative. The larger households comprised besides the family proper one or more single men (laborers, etc.). Hence the preponderance of males.

ii. Columns (a) and (b) tally pretty well with column (d), i. e. the number of plague cases. The figures in column (c) indicate a considerably smaller number of men. But these were collected among families unwilling to submit to our measures: we may assume therefore that many of the adult males absconded while the less active women (and children) stayed behind.

iii. Therefore the higher incidence of male cases results principally from the proportion of sexes in the population. In other words this is of an accidental nature and not due to any difference in the susceptibility of the two sexes against plague. Similar experiences were noted in India (15). There, however, it was concluded "with probability that the percentage of cases among women has been greater than the percentage among men". This was ascribed to the more confined life of the former, exposing them more than the men "to the

risk of contracting the disease from the infection lurking in infected houses". It would seem that such influences were not at work in the Tungliao region.

2. Age incidence.

Our collected statistics give the following :

	Chien-Chia-Tien		Tungliao		Sanlin		Chan-Yu		Total	
	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent
0-10	8	7.7	1	9.1	2	8.7	15	24.2	26	13.0
11-20	22	21.2	3	27.3	3	13.0	14	22.6	42	21.0
21-30	18	17.3	1	9.1	8	35.7	14	22.6	41	20.5
31-40	19	18.3	3	27.3	6	26.0	8	12.9	36	18.0
41-50	11	10.6	1	9.1	3	13.0	3	4.8	18	9.0
51-60	15	14.4	2	18.1	1	4.3	6	9.6	24	12.0
61-70	7	6.7					1	1.6	8	4.0
71-80	4	3.8							4	2.0
81-90							1	1.6	1	0.5
Totals	104		11		23		62		200	

These figures may be tabulated together with the age incidence among the population :

	Isolated in camp		Isolated in houses		Plague incid.	
	No.	per cent	No.	per cent	No.	per cent
Below 12 yrs.	55	30.2	196	44.5	8	7.7
Above 12 yrs.	127	69.8	244	55.5	96	92.3

As can be seen, the plague incidence among children was considerably lower than should be expected from their numbers. This is not surprising because similar experiences have been encountered in India (16). There the Plague Commission stated "that the incidence of plague during the first five years of life is much less relatively to the number of persons of this age in the population than it is at any other period of life" and added that "there would seem to be - though the figures are less clear on this point - a similar, though less marked diminution, in the incidence of plague at the other extreme of life". We do not possess sufficient data to postulate upon the incidence among the aged in the Tungliao District.

3. *Duration of illness (in days):*

Days	Chien-Chia-Tien		Tungliao		Sanlin		Chan-Yu		Total	
	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent
1	1	1.0					3	4.9	4	2.1
2	2	2.1					19	31.5	21	11.3
3	7	7.4	5	56.0	3	13.0	18	29.8	33	17.7
4	22	23.5	2	22.0	12	52.1	12	19.9	48	25.8
5	19	20.3	1	11.0	6	26.0	5	8.3	31	16.1
6	12	12.8	1	11.0	1	4.3	1	1.6	15	8.0
7	11	11.7					1	1.6	12	6.4
More	20	21.4			1	4.3	1	1.6	22	11.8
Total	94		9		23		60		186	

Our table, comprising a few recoveries besides a large majority of fatal cases, shows:

- That a duration of one day was rather rare (2.1%);
- That the percentage then quickly rises reaching its maximum (25.8%) on the fourth day after which it falls slowly.

It would seem that the duration of illness as observed in the Tungliao region in 1928 was somewhat longer than in India. At least the Indian Plague Commissioners, basing their conclusions (17) upon an aggregate of 3,035 *fatal* cases, state that:

- In about one sixth of the cases (i. e. ca. 16%) death occurred within 24 hours;
- The maximum was reached on the second and third days (20.3 and 18.9% respectively) the number of deaths then gradually lessening until the 8th day, by the end of which 93% of the patients had died.

4. *Type incidence.*a. *General incidence in different areas.*

	Chien-Chia-Tien		Tungliao		Sanlin		Chan-Yu		Total			
	No.	<i>per cent</i>	No.	<i>per cent</i>	No.	<i>per cent</i>	No.	<i>per cent</i>	No.	<i>per cent</i>		
<i>Bubonic</i>	Inguinal	32	31.6	4	50.0	19	82.6	37	64.7	59	52.7	
	Femoral	7	6.9									
	Axillary	20	19.8		0	0.0	4	17.4	6	10.5	30	15.9
	Cervical	8	7.9		1	12.5	0	0.0	6	10.5	15	7.9
	Popliteal	1	0.9		0	0.0	0	0.0	0	0.0	1	0.5
	Cubital	1	0.9		0	0.0	0	0.0	1	1.7	2	1.0
	Multiple	11	10.8		0	0.0	0	0.0	1	1.7	12	6.3
Total bubonic	80	78.8	5	62.5	23	100.0	51	89.1	159	84.3		

	Chien-Chia-Tien		Tungliao		Sanlin		Chan-Yu		Total	
	No.	<i>per cent</i>	No.	<i>per cent</i>	No.	<i>per cent</i>	No.	<i>per cent</i>	No.	<i>per cent</i>
Septicemic	18	17.8	3	37.5	0	0.0	6	10.5	27	14.3
With pneu- monic features	2	1.9	0	0.0	0	0.0	0	0.0	2	1.0
Skin plague	1	0.9	0	0.0	0	0.0	0	0.0	1	0.5
Totals	101		8		23		57		189	

We propose to use here the material observed at Chien-Chia-Tien only, since in other localities it was not always possible to establish the nature of the cases with desirable accuracy.

Our limited Chien-Chia-Tien figures may be compared with more comprehensive Indian statistics :

i.

	Chien-Chia-Tien		Indian Plague Commission (18)	
	No.	<i>per cent</i>	No.	<i>per cent</i>
Total bubonic c.	80	78.8	9,945	81.9
Total non-bub. c.	21	20.6	2,200	18.1
	101		12,145	

ii.

	(1) Chien-Chia-Tien	(2) Bombay (19), 1900	(3) Bombay (20), 1907
	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>
Simple bubon. c.	78.8	78.15	92.8
Septicemic c.	17.8	14.25	2.4
With pneumonic features	1.9	4.10	1.0
Skin c.	0.9		3.7
Atypical	0.0	3.50	0.0

We may summarise the observations outlined above :

a. The percentage of bubonic and non-bubonic cases (i) as observed by us at Chien-Chia-Tien coincides fairly well with early Indian statistics as published in 1901.

b. The incidence of uncomplicated bubonic cases (ii) at Chien-Chia-Tien in column (1) was almost the same as that observed by Choksy early in the pandemic (2). It is, however, lower than in his later statistics (3) comprising the years 1896-1907. The non-bubonic cases in columns (1) and (2) do not correlate so well, both pneumonic and atypical cases (the latter apparently comprising skin cases) being rather more frequent in India than at Chien-Chia-Tien in 1928 with a corresponding decrease in the number of septicemic cases. The figures in column (3) show no similarity to ours.

c. On the whole, it seems safe to say that our data collected in 1928 in the recently invaded Tungliao area bear a marked resemblance to those compiled early in the present pandemic in India.

b. *Bubo incidence in different areas.*

	Chien-Chia-Tien		Tungliao		Sanlin		Chan-Yu		Total	
	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent
Inguinal	32	40.0	4	80.0	19	82.6	37	72.5	99	62.3
Femoral	7	8.7	0	0.0	4	17.4	6	11.7	30	18.9
Axillary	20	25.0	1	20.0	0	0.0	6	11.7	15	9.4
Cervical	8	10.0	0	0.0	0	0.0	0	0.0	1	0.6
Popliteal	1	1.2	0	0.0	0	0.0	1	1.9	2	1.2
Cubital	1	1.2	0	0.0	0	0.0	1	1.9	12	7.5
Multiple	11	13.7	0	0.0	0	0.0	1	1.9		
Totals	80		5		23		51		159	

Comparison of 80 Chien-Chia-Tien cases with 9,500 cases summarised by Choksy (21) in 1900 is as follows:

	Chien-Chia-Tien	Bombay
	per cent	per cent
Cervical	10.0	8.40*
Axillary	25.0	21.85
Femoral	8.7	30.87
Inguinal	40.0	23.25
Multiple	13.7	12.95
Other situations	2.4	1.68

*Including 1.68% parotid buboes.

We naturally hesitate to draw any rigid conclusions from our limited material. However, we have every reason to consider our 80 cases as representative and can assert that much care was taken to verify them, our personnel being specially instructed to differentiate between inguinal and femoral buboes.

From the above table, it can be seen that except in buboes of the groin region the Indian figures and our own harmonise nicely. The Indian total of 54.12 per cent of groin cases is made up of 30.87% femoral and 23.25% strictly inguinal buboes, while our total of 48.7% comprises only 8.7% femoral cases as against 40 per cent strictly inguinal ones.

At first glance it might seem that this discrepancy is due to the different style of dressing between Indians and northern Chinese: the latter not only wear shoes all the year round but also tie their trouser ends over close-woven cotton socks at the ankles. Most Indians either go bare-footed or wear sandals only.

The Indian Plague Commission has pointed out (22) that a striking coincidence exists between the figures of bubo incidence in the cervical, axillary and inguinal regions respectively and those indicating the size of areas draining into these gland groups. The result of these investigations was "that in proportion to the area of skin which drained into them the glands of the groin were not more commonly affected than the glands of the axilla or of the neck" (23). Writing in 1901 (22) the Commissioners had not sufficient material to compare the frequency of groin buboes in persons walking bare-footed and with shoes, though quoting observations of Aoyama (Formosa) which showed that such buboes were more frequent in Chinese (who walk bare-footed on that island) than in Japanese (who wore shoes). The "Summary of the Work of the Plague Commission" (23), published in Calcutta, 1908, however, distinctly states "that in communities wearing shoes the presence of groin buboes is no less than in those who go about bare-footed".

It would seem that the difference in the frequency of inguinal and femoral buboes, as noted above, cannot be satisfactorily explained by different modes of dressing. Moreover, there is reason to assume that infection occurs not so much in the day as at night-time. In the Tungliao district our Chinese remove all clothes before sleeping and only cover themselves with bedding which varies in thickness according to the season of the year.

In the second part of this article we shall bring evidence showing that in Chien-Chia-Tien at least, as different from India, *human* parasites could play a rôle beside the rat-flea in the spread of infection. One

wonders if this difference may have some influence upon the bubo distribution. We propose to keep this point in mind in future investigations.

5. *Symptomatology.*

a. *Bubonic cases.*

Most of our cases displayed the classical features of the disease. There was high fever (102-104° F). The pulse was soft and its rate markedly increased from the beginning. The face of the patients wore usually a peculiar anxious expression and often became flushed. The eyes were blood-shot: the tongue soon became dry and furred. In addition to painful buboes the sufferers complained of headache and backache. Delirium was sometimes present. A staggering gait and loss of balance was the rule. Some patients showed a marked "Wandertrieb" attempting to run away from the hospital. Symptoms of air hunger were frequently displayed, the sufferers wanting to leave the room in order to sit or lie in the court-yard: sometimes they suddenly died during such attempts. In most cases death, evidently due to heart failure, came on suddenly. In a minority there was marked agony accompanying odema of the lungs.

The size of the buboes showed much variation. On one hand these were marked in size, on the other very small ones were met with, which could be hardly detected by objective examination. In fact one had the impression that these cases with slight buboes form a gradual transition to the 'septicemic' ones.

A few instances were noted where fever was low or absent throughout the disease. These invariably died quicker than the ones with marked reaction.

In spite of the constant vigilance of our own selves and trained assistants who had gone through the 1921 Harbin epidemic, we failed to detect any clinical signs pointing to secondary involvement of the lungs in the cases with manifest buboes.

b. *Septicemic cases.*

The general appearance of the non-bubonic cases was on the whole similar to that displayed by bubonic victims. Dyspnoea seemed marked and there were often subjective complaints of tightness and oppres-

sion in the chest. Cyanosis as a rule was more marked. Like the bubonic cases the sufferers displayed progressive symptoms of heart failure resulting often in sudden death.

From a theoretical standpoint it would seem that 'septicemic' patients, who show such small resistance to the invaders that the lymphatic glands are overrun without the formation of buboes, are likely to succumb quickly. Practical observations have not wholly confirmed this. In the clinical summary appended to the Report of the Indian Plague Commission (24) it is stated that "death occurs in pneumonic cases, and generally, but less invariably, also in septicemic cases, in from less than one day to three days". Philip and Hirst's experience, in a prevalently septicemic outbreak at Colombo (25), was that average cases displaying this feature of plague ran a course of 36 to 48 hours. Heiser, in his 1922 summary on Bubonic Plague (26), says that in septicemic plague "the patient usually succumbs within three or four days and before the appearance of buboes". Our limited observations at Chien-Chia-Tien often showed an even more prolonged course:

Duration of illness in 14 fatal septicemic cases:

3	days	1
4	"	2
5	"	4
6	"	0
7	"	3
8	"	1
More	"	3
		<hr/>
		14.

C. Cases with pneumonic features.

It has already been emphasised that symptoms of secondary lung involvement appeared to be absent in cases with manifest buboes. Two instances were encountered by us where no buboes were present and the lungs showed definite signs of pneumonia.

- i. Mahomedan practitioner, male, aet. 32, fell ill on September 23. Refused to be attended by our Medical Officer during life by locking himself up in house. Had evidently visited several plague patients. Apparently died early on September 29 and was dissected same noon. No outward signs of cough or haemoptysis.
- ii. Poor man, aet. 54, was supposed to have got sick on Sept. 24. Admitted into hospital on October 4, in serious condition. No external buboes felt. Marked and constant cough with viscous partly stained (dark red) sputum—not the usual pinkish sputum of pneumonic plague. But *B. pestis* were plentiful under microscope.

Pt. died at day-break October 5, and was dissected same morning.

Both cases will be discussed in the second part of this article.

6. *Recovering cases.*a. *Chien-Chia-Tien.*

Though we possess data for only 12 recoveries we have reason to believe that - especially earlier in the epidemic - a number of slight and quickly recovering cases (*Pestis minor*) remained undetected.

Details regarding the known cases are as follows :

No.	Sex	Age	Localisation of buboes	Duration of illness (in days)	Remarks
1	F.	32	Cervical	11	Mother died of bubon. pl. (groin) 5 days before pt. fell ill, husband 5 days after. Punctate of cv. bubo pos. for. <i>B. pestis</i>
2	F.	8	No marked bubo, only high fever	5	Mother of pt. died of plague
3	M.	16	Popliteal	15	Bubo broke eventually ; no pus, only a brownish hemorrhagic fluid was voided
4	M.	22	Femoral	8	
5	M.	16	Fem. and inguin.	16	
6	M.	15	Bilat. axillary	13	Father, mother and brother of pt. succumbed Recd. 1 c.c. vaccine when falling ill
7	M.	18	Inguin. ax.	10	Recd. 1 c.c. vaccine when falling ill
8	M.	32	Axillary	?	Recd. 20 c.c. serum and 3 c.c. vaccine when falling ill
9	M.	27	Inguinal	8	Recd. 1 c.c. vaccine when falling ill
10	F.	32	Axillary	10	
11	F.	? (old)	Buboes in both groins	?	Was found ill when arriving at quarantine camp on Sept. 29
12	F.	54	Cervical	14	Son's wife died of plague in same house Much pus flowed from healing bubo. Refused treatment

The following remarks may be offered :

i. With two exceptions (both old women) none of our recovering patients was past 32 years, a majority being under 25. Early Indian experiences were that plague was least fatal to very young and very old persons, the maximum of fatality being reached between 50 and 60 years of age (27).

ii. The number of our cases is too small to draw any conclusion regarding a correlation between bubo localisation and prognosis. The great variety of bubo localisation and the comparative frequency of multiple buboes deserve notice.

iii. One case, a girl, aet. 8, showed no buboes, only high fever and serious general symptoms when first examined by one of us (W. L. T.) on Sept. 16. When seen again on Sept. 20, she was quite well, able to walk about. Since she could not be properly examined during the interval, we cannot assert with certainty that external buboes were absent.

iv. Recovery took place gradually as a rule after one to two weeks.

v. The vaccine produced from a local strain was used for some patients as well as the usual contacts. A number of the former were apparently benefited.

b. *In other localities.*

Two recoveries noted outside of Chien-Chia-Tien are :

Locality	Sex	Age	Localisation of	Duration of illness
Sanlin	M.	23	Femoral	20 days
Chan-Yu	M.	23	Inguinal	12 "

C. LABORATORY ACTIVITIES

1. *Vaccine preparation.*

As can be gathered from Part I of this report Dr. Chun of our Service managed on September 7, to puncture the femoral bubo of a dead body. Besides several smears he made cultures which he speedily took to Harbin. As was to be expected under the difficult conditions he worked these were slightly contaminated. Pure growths of this

strain were subsequently obtained by guinea-pig passages and these were used for vaccine preparation.

Our technic is as follows :

a. *Apparatus required :*

i. *Bottles of nutrient agar.* Ordinary flat-shaped dispensary bottles (200 c.c.) are used. 50 c.c. slightly alkaline agar are poured into each bottle which is then closed with a cotton plug and oil paper cap and slanted after autoclaving.

ii. *Flask (5-10 liters) for collecting vaccine.* The cubic contents of this flask are measured beforehand with the aid of known quantities of water. After this has been dried it is closed with a plug and funnel; the latter is then covered with some layers of thick paper and tied down before autoclaving.

iii. *Syphon apparatus* mounted on a rubber stopper which fits into flask. (ii)

iv. *Flasks* containing known quantities of sterile *physiological salt solution* mixed with 0.5 % *pure carbolic acid*.

v. *Cork-stoppered small bottles* to hold the vaccine. Sizes are of 3 c.c., 30 c.c. and 60 c.c.

vi. Assorted *pipettes, centrifuge tubes, agar tubes, tubes with physiological salt solution or bouillon*, etc.

All glassware is first sterilised in the hot-air box. All apparatus, each duly prepared and wrapped, and then autoclaved.

b. *Preparation of original culture.* The cultures used for the preparation of anti-plague vaccine should fulfil two main requirements :

- i. Fresh local strains to be used ;
- ii. Cultures to be absolutely pure.

Several slants of a suitable culture are prepared and carefully tested. If these are entirely satisfactory, emulsions are prepared by distributing loopfuls of the original cultures in tubes containing bouillon or physiological salt solution.

c. *Inoculation of the agar bottles.* The agar bottles are inoculated with the aid of small pipettes, a few drops of the emulsion being run into each. The bottles are quickly closed again and gently tilted to and fro so as to cover the whole agar surface with the emulsion. This is easy since freshly prepared agar is rich in condensation water.

d. *Incubation of agar bottles.* The bottles are then incubated in a horizontal position at a temperature of 28-30°C. If the agar is prepared with fresh beef and good (Witte's) peptone is used, sufficient growth is obtained within 48 hours.

e. *Washing off the growth.* 10 c.c. of carbolised physiological salt solution are poured into each bottle through pipettes. By gently shaking the bottles to and fro it is easy to wash off the growth. After this the bottles are kept standing.

f. *Testing the growth.* Smears are taken from each bottle with a long platinum wire and stained with diluted carbol fuchsine (each slide bearing a number

corresponding to the bottle). The smears are inspected and whenever there is the slightest suspicion of impurity, the bottle in question is discarded.

NB. It might seem superfluous to examine each bottle. However, long experience has convinced us that this extra trouble is worth while and better than risking a whole lot of vaccine.

g. *Collection of vaccine.* The contents of the individual bottles are then poured into the large flask (ii), the empty bottles being carefully deposited in a large tin bucket (where they are afterwards boiled). The funnel is replaced by a sterile cotton plug and the contents of the flask are well mixed. For this purpose some glass beads have been inserted before sterilisation.

h. *Inactivation of vaccine.* The flask is heated in a large water-bath for 1-2 hours at a temperature of 60-62°C, its contents being stirred every few minutes.

i. *Standardisation of vaccine.* For this we use a simple method recommended by the Japanese (28). Two dry centrifuge tubes are carefully weighed, then filled with a known quantity of the vaccine and centrifugated, in the electrical centrifuge for quarter of an hour at a speed of 1,500 revolutions per minute. The supernatant liquid is then decanted, the last traces of moisture being removed with filter-paper strips. By weighing the tubes again the bacterial contents per c.c. can be calculated, the average value of the two determinations being taken.

j. *Testing the concentrated vaccine.* Together with the samples for standardisation a sterile one is taken for cultural and experimental tests. We inoculate agar slants and stabs as well as bouillon tubes and inject two guinea-pigs (subcutaneously and intraperitoneally) with $\frac{1}{2}$ c.c. each

k. *Dilution of vaccine.* If the cultures are found satisfactory the vaccine (which has been kept in the meantime in a dark cool store room) is diluted with carbolised physiological salt solution so as to contain 6 milligram of killed bacteria per c.c.

l. *Filling and final testing.* With the aid of the syphon apparatus the diluted vaccine is distributed among the small bottles. After proper corking the neck portion is dipped into melted paraffine. Cultures as above are made from the last bottle for final testing.

m. *Issuing the vaccine.* The diluted vaccine (which is kept cool and dark) is only labelled and issued after all cultures have been found perfectly sterile, and the test animals have remained healthy for at least 10 days. Dosage is 1 c.c. for the first and 2 c.c. for the second injection with an interval of 8 days.

n. *Precautions taken.* So long as the plague bacilli are not killed by heating, all our work is performed in a special room devoted entirely to the purpose. No bystanders are allowed and all workers wear anti-plague costume with rubber gloves and masks. The dangers of preparation of anti-plague vaccine should not be underrated as shown by at least two instances of laboratory infection during such work (1). And, though the above procedure might appear simple, there are many pitfalls as well as dangers for the inexperienced.

Altogether we prepared 40,000 c.c. of vaccine during the epidemic. While most of this was destined for the Tungliao and adjacent districts, lots were also sent to Outer Mongolia (Urga) and Shansi Province (Fenchow).

We do not possess sufficient data to prove the value of vaccination by statistics. As far as our knowledge goes, however, none of the twice inoculated fell ill and even a single dose seemed quite sufficient to prevent sickness and even instrumental in several instances in curing it. A few persons fell ill with plague within 1-3 days (usually within 24 hours) after vaccination, having obviously been in the incubating stage when inoculated. It is clear that such inevitable incidents tend to discredit the method in the eyes of even intelligent laymen. In our case it was fortunately possible to dispel such prejudices early, the people as a rule submitting willingly to the inoculations. The main objection came when a second injection was suggested.

Our vaccine produced a marked but not too strong local and general reaction which usually passed off after 12-24 hours. The reactions were carefully studied among the higher staff. No untoward incidents were ever met with, the injections being always performed under strict aseptic precautions.

2. *Establishment of Field Laboratory at Chien-Chia-Tien.*

Though a definite diagnosis of bubonic plague was early arrived at, the Tungliao region was in many epidemiological respects a *terra incognita*. It was not established if and how far rodents took part in the spread of infection, and what species were involved. The early reports spoke mainly of importation through human agency, only a few observant inhabitants remarking upon an abundance of rats before the outbreak and their disappearance soon afterwards. To solve these and related problems as well as to carry out routine work it was decided from the first to establish a field laboratory at Chien-Chia-Tien. This plan was realised on September 25, and work started the next morning.

The laboratory was housed in a wing of the (unused) goods registration office of Chien-Chia-Tien station, a red brick solid building free from rats. Only one fairly large room with excellent north light was at our disposal. This limited accommodation rather curtailed our plans, but we were glad at the time to have even this. We accommodated the healthy laboratory animals in our living quarters

next door but the infected ones had to be kept in the laboratory proper; therefore it did not seem wise to perform any experiments with living parasites in the room. Living rats and wild rodents were not brought into the laboratory but confined in covered tins or large basins in the open and had to be killed off as soon as possible. Otherwise, by conforming to strict order and cleanliness, we felt little hampered in our work.

A formal routine for the day was quickly established. Leaving our sleeping quarters in suitable underclothes and slippers we donned outside the laboratory our anti-plague costume consisting of (i) a special one-piece overall similar to a clown's garment which was tied at the neck and wrists, (ii) rubber gloves and boots, (iii) mask and cap. We then proceeded at 8 a.m. to the village (1/4 mile away), the required apparatus being arranged in two tin buckets carried by a special attendant. After the morning's work in the village was over we returned to the laboratory where the material was at once studied and preserved if necessary. Dissected animals were immediately cremated after autopsy in a small two foot deep pit dug nearby; all other infectious material was also burnt or otherwise disinfected. Only after everything had been cleared up did we undo our costume and return to the living quarters, usually at 5 p.m. Besides ourselves only one experienced assistant had access to the laboratory which was always kept locked during our absence.

We may now deal *seriatim* with the different phases of our work.

3. *Human post-mortems.*

It has been mentioned already that we performed our autopsies next to the cremation pit away from the village in order to facilitate disposal of the corpses and to allay the suspicions of the populace. Dissection was done upon the cadavers lying on the bare ground, the operator kneeling or squatting on a low foot-stool. Dusty and rainy days were often experienced while in warm weather we were much bothered by bottle flies. It is obvious that under such circumstances the work could not be performed with the leisure and completeness possible in a properly equipped *post-mortem* room. Nevertheless we hope that the data collected under such difficult conditions will prove of interest.

In performing autopsies we adopted such precautions as had proved of value in Harbin in 1921. Only one of us performed the actual section, the other and the

dresser assisting with smears, cultures, etc. The actual operator donned an extra overall and a second pair of long *post-mortem* gloves. After the autopsy the instruments were placed in a pan (to be sterilised after return to the laboratory), the gloves were disinfected with spirit and then immersed in a pot containing 5% carbolic acid solution while the overall (though usually not visibly contaminated) was boiled.

The results of our 15 autopsies are summarised as follows :

No.	Sex	Age	Duration of illness(days)	Post-mortem Diagnosis	Smears	Cultures	Experim.
1	M.	75	4	Septicemic pl.	+	+	None
2	M.	32	4	Pl. with pneumon. features	+	+	+
3	M.	31	5	Bubon. pl. (axill.) with sec. bacter.	+	None	None
4	F.	30	5	Bubon. pl. (femor.) with sec. bacter.	+	+	"
5	M.	61	5	Septicemic pl.	+	+	+
6	M.	64	2	Skin plague	+	+	None
7	F.	20	7	Septicemic pl.	+	+	"
8	M.	54	8	Pl. with pneumon. features	+	+	"
9	M.	71	?	Septicemic pl.	+	+	"
10	M.	20	6	Bubon. pl. (femor.) with sec. bacter.	+	None	"
11	M.	67	3	Bubon. pl. (inguin.) with sec. bacter.	+	"	"
12	M.	75	4	Bubon. pl. (cubital) with sec. bacter.	+	+	"
13	M.	15	3	Septicemic pl.	+	+	+
14	M.	62	?	No plague	-	-	None
15	M.	30	4	Septicemic pl.	+	+	"

According to type the above cases were thus classed :

Bubonic plague 5 (Nos. 3,4,10,11,12)

Septicemic plague 6 (Nos. 1,5,7,9,13,15)

Pl. with pneumo- nic features	2 (Nos. 2,8)
Skin plague	1 (No. 6)
No plague	1 (No. 14)

Total 15.

We proceed now to a preliminary description of the salient features met with in these various types.

a. *Bubonic cases.*

i. *Buboes.*—Though the buboes met with in our series were as a rule comparatively small in size, they always showed well marked and characteristic features, the substance of the involved gland or glands being hemorrhagic, the surrounding oedema varying in area.

Skin hemorrhages over the bubo (as well as other parts of the body) were usually absent. A noteworthy exception to this rule was Case 12. Here at autopsy a hemorrhage (size of a half-dollar) was noted in the skin over the right cubital region: traces of acupuncture (needling) could be clearly seen at the periphery. A small lump was felt in the subcutaneous tissue which on section showed a rather uniform, dark-red color. Macroscopically it was impossible to decide whether this corresponded to a small cubital bubo or was merely due to traumatic hemorrhage, the inner aspect of the elbow being a spot often chosen by native practitioners for needling. Histological investigation proved the presence of a bubo with marked necrosis, the surrounding tissue showing severe hemorrhage but little infiltration with round cells.

Under the microscope advanced alterations (hemorrhagic inflammation and necrosis) were the rule, leading to more or less complete destruction of the normal gland structures. Usually only small remnants of adenoid tissue could be recognised. The walls of the blood vessels were often swollen and of a homogeneous appearance with badly stained nuclei. Periadenitic changes were marked in every case and consisted of infiltration with round cells, hemorrhage and even necrosis.

Plague bacilli were specially numerous in the buboes proper. They were either evenly distributed (Cases 4 and 12) or more grouped

together, often forming large nets or clusters (Cases 3 and 10), or masses were found in addition to many isolated bacilli throughout the substance (Case 11).

ii. *Lung*.—Pleural exudate was noted twice: Case 11 (with inguinal bubo) had some dark-red serous liquid in both pleural cavities, while a moderate amount of a clear fluid was present at the left side in Case 3 (left axillary bubo with widespread surrounding oedema). Subpleural petechiae were seen only in Case 10. The lungs were usually markedly congested, sometimes oedema was present as well. Though constant attention was paid to this point we could not detect any macroscopic signs of consolidation.

Four out of our five cases were investigated histologically. They all showed in addition to marked congestion small and often irregularly shaped foci of bronchopneumonia, the involved alveoli being filled with a serous or cellular exudate or a combination of both. As a rule erythrocytes greatly outnumbered white cells.

Plague bacilli were scanty in Cases 4 and 10. In Case 12 they were fairly numerous not only in the vessels and peribronchial lymphatic tissue but also at places in the involved alveoli, though not so plentiful as in cases of primary pneumonic plague. Many bacteria were seen throughout the lungs of Case 11, the majority being extraneous organisms.

iii. *Liver*.—The liver usually showed signs of acute parenchymatous degeneration. Yellowish, well defined patches were often noted at the surface in addition to subcapsular hemorrhages.

Microscopically we invariably encountered marked parenchymatous changes. Small areas of necrosis were frequently noted and occasionally small hemorrhages (into necrotic areas?). More or less dense infiltration of the spaces surrounding the portal vessels was the rule.

Plague bacilli in vessels and capillaries were scanty in Case 3, very numerous in Case 12, fairly so in the others: they often formed minute groups or clusters.

iv. *Spleen*.—The spleen was markedly enlarged in two instances (Nos. 10 and 12), moderately so in Case 3; in the first two its consistence seemed softer than normal. The organ always appeared rich in blood. Follicles and trabeculae often could not be recognised with the naked

eye; an exception was in Case 11 (aet. 67) where the trabeculae were prominent (no doubt through age). Well marked subcapsular hemorrhages were rarely noted while advanced features (like necrosis, infarct) were altogether absent.

Microscopically the organ was invariably rich in blood. Hemorrhages were apparently present. The follicles were often smaller than normal, in some instances markedly so, and scarce in numbers. Their central vessels were distinctly changed, the walls appearing thickened and more or less homogeneous. Hyaline degeneration of the trabeculae was frequently encountered. As far as we are aware, areas of necrosis were not particularly frequent. Plague bacilli were more or less numerous, being either evenly distributed or (rarely) arranged in small groups or clusters; they were absent or scanty in the follicles. In Case 3 bacilli were present in small numbers (while large clusters were seen in the bubo around the necrotic areas and adjoining parts).

b. *Septicemic cases.*

We turn now to the group of cases which, for the sake of brevity, have been designated as 'septicemic' plague though this term is a misnomer for various reasons. Most, one might almost say practically all, fatal plague cases display features of septicemia or better bacteremia at autopsy. Clinical observations with adequately exact methods have shown that at least a transient bacteremia is a frequent event in plague cases of all descriptions; in fact some observers assume that this obtains in every or almost every instance. If on the other hand the term 'septicemic' plague is reserved for cases without a manifest, primarily local process, this might lead to the impression that these are due to a direct blood infection. Now the existence of such plague septicemia in the strict sense is denied by most authorities and no satisfactory proof has been brought forward to contest them.

For all these reasons it would be better to adopt another name for the so-called septicemic cases. For such lung plague with no manifest pneumonia we have proposed the designation of *pulmonary* plague which satisfactorily indicates both their common etiology with, and their distinction from, true pneumonic cases. No such short name exists for 'septicemic' cases met with in bubonic epidemics; they have to be styled "with early septicemia" or "without superficial buboes" as

suggested by Crowell (29) or perhaps more satisfactorily, though longer, "without manifest primary buboes". To designate them merely as cases without manifest buboes would not be quite correct since—as recognised by the Indian Plague Commission already (30)—moderate yet characteristic changes are met with in "all, or nearly all, of the lymphatic glands of the body, although in many instances the affected glands were chiefly those of the mesentery". Albrecht and Ghon (31) who in the course of their painstaking researches found but three cases where they did not succeed to recognise a primary bubo, noted in these "multiple gland swellings with features of secondary (metastatic) buboes".

It can be gathered from the foregoing passage that the diagnosis of 'septicemic' plague is a difficult one. In fact it might seem necessary from a theoretical standpoint to examine the various gland groups not only by careful inspection, palpation and even dissection but also by histological methods—requirements difficult or impossible to fulfil under field conditions. Perhaps there is no need for such foregoing demands. Both 'septicemic' and bubonic plague as ordinarily met with are due to one and the same mode of infection. Possibly no sharp borderline exists, cases with small and comparatively little changed primary buboes intervening between the two types.

Be this as it may, we feel confident that manifest primary buboes were absent in our six cases, two of which were seen before as well as after death.

i. *Case 9*, dissected on October 6.—This patient, aet. 61, was seen by us on October 5. Though appearing weak he did not seem to suffer from plague or any other acute disease. In fact our staff, who had examined him, asserted that he was merely starving. He was, however, found dead on the morning of October 6, plague without manifest buboes being diagnosed at autopsy.

ii. *Case 5*, dissected October 3.—This patient, a Mongol, aet. 61, fell ill on September 28. When first seen by us on Sept. 30, he showed marked general plague symptoms (flushed face, blood-shot eyes, coated tongue, fever, quick pulse, etc.). He did not complain of any glandular swellings, only of headache and a feeling of compression in the chest. No cough. No buboes were found by objective examination.

On the next day he was again examined (and his photo 23 taken). Condition little changed. Examination of the faucial organs showed some congestion but no ulcerative process.

On Oct. 2, he managed to escape from the hospital to his miserable abode nearby. Here we found him in a critical condition: Cyanosis was marked and the pulse of bad quality. Some dried blood was noted on the back of his nose, he having apparently fallen down during his flight. (There had been marked loss of balance since October 1.) No cough or expectoration.

He died in the course of October 2, and was dissected next morning, plague without manifest primary buboes being found at autopsy.

The *post-mortem* findings in the six cases now under discussion were on the whole rather similar to those in the bubonic series. The following points deserve discussion:

1. The absence of primary external buboes has already been emphasised. Moderate alterations in the glands, evidently identical to those described by the Indian Plague Commission, were met with.

2. The mesenterial and also the anterior mediastinal glands were sometimes markedly changed, being enlarged and much congested. Histological examination revealed marked congestion. Hemorrhages were occasionally met with but never led to advanced destruction of the gland tissue. Periadentitic changes, especially small hemorrhages, were sometimes present but always moderate. Plague bacilli varied in numbers, being sometimes scanty, sometimes rather numerous and evenly distributed.

3. Except case No. 13, where beginning hypostatic pneumonia seemed present, the lungs showed macroscopically only marked congestion (sometimes oedema) with occasional subpleural petechiae. Microscopically small bronchopneumonic foci similar to those encountered in the bubonic cases were the rule. Plague bacilli were usually scanty in the lungs; only in post-mortem 9 were these numerous in some of the small pneumonic foci.

4. In general the number of plague bacilli met with in these 'septicemic' cases was not larger than in the bubonic ones. In one instance (Case 18) a few bacilli were seen in smears from spleen and lungs as well as in sections from these organs and the liver. Only few colonies grew in spleen cultures. In order to confirm the diagnosis, a guinea-pig was infected percutaneously with a loopful of this culture. It succumbed to typical bubonic plague with secondary bacteremia.

c. Skin plague.

The case to be discussed now (No. 6) is that of a Chinese, aet. 64, who was said to have been ill for two days only. At autopsy undertaken a few hours after death on October 4, a plague carbuncle (size of a silver dollar) was found over the left pectoral muscle. It was circular in shape and prominent. A flat blister had evidently formed over it and burst, the markedly injected corium lying bare at places. Sections perpendicular to the surface showed the tissue to be

infiltrated, juicy, in general of a whitish color with a few small, somewhat softer and yellowish areas. No primary bubo was detected. Some old pleural adhesions were present. The lungs were congested and oedematous. Heart and mediastinum showed no conspicuous changes. The liver displayed subcapsular hemorrhages and signs of severe degeneration as usual. Spleen was markedly enlarged, congested and soft.

Smears from the carbuncle showed a fair number of plague bacilli, from the lungs less. Positive cultures were obtained from the carbuncle as well as from the spleen.

Sections from the carbuncle showed advanced necrosis of the epidermis, only shadows of nuclei and of cell outlines being recognisable at places in a uniformly contrast-stained mass. Necrotic areas were present in the corium where they alternated with foci showing moderate round-cell infiltration. In the subcutis areas with dense leucocytic infiltration were noted. Plague bacilli were numerous in the infiltrated parts of the corium and subcutis especially where they formed nets or clusters.

Histological investigation of the lungs showed congestion and minute areas where a few alveoli were filled with a partly serous, partly cellular exudate, white corpuscles preponderating.

The microscopic changes in liver and spleen were identical with those found in the preceding series.

Though we failed to detect a primary external bubo we are far from asserting that the carbuncle constituted the portal of entry of the infection. We think it far more likely to be due to a secondary infection through the blood stream. As will soon be discussed, such metastatic foci may form in spite of the absence of manifest primary buboes.

d. *Plague with Pneumonic features.*

The clinical histories of these two cases have been given in the first part of this report. Autopsy findings were :

Case 2, dissected on September 29, i.e. a few hours after death.

No external primary bubo found. Lungs were congested and showed a few small nodes (with a diameter up to $\frac{1}{2}$ cm.), situated mostly beneath the pleura. They were slightly bulging and the small pleural vessels over them were often

markedly injected. The nodules themselves were round in shape, well defined, rather firm in consistence and of a reddish or yellowish color.

The liver displayed the usual changes, the spleen was moderately enlarged and softer than normal.

Only few plague bacilli were seen in smears from lung and spleen; more from the liver. Cultures from all three organs yielded plentiful and typical growth. Positive experimental results were obtained with the lung culture.

Histological examination of the lung nodules showed the alveoli to be filled with a partly serous, partly cellular exudate, white blood corpuscles preponderating on the whole. Plague bacilli were quite plentiful, especially where a cellular exudate was present.

In apparently unconsolidated parts of the lungs small foci were found where groups of alveoli were filled either with erythrocytes or with a partly serous, partly cellular exudate. Here bacilli were less numerous; occasionally, round blood vessels, large clusters were seen.

Liver and spleen displayed the usual changes but contained comparatively few bacteria.

Case 8, died October 4, dissected next day.

Undernourished man, aet. 54. Some thin bloodish fluid trickling from nose and mouth. External primary buboes appeared to be absent. Faucial organs and oesophagus free from conspicuous changes. Trachea was rather pale; in its lower part some foamy pink sputum was adherent to the walls. Peritracheal glands were not markedly changed. The mucosa of the bronchi was much congested.

Both lungs were congested; each contained a few nodes with a diameter up to two centimeters. These were situated either on the surface (then slightly bulging) or more deeply in the substance. Over the largest node in the right middle lobe a layer of fibrinous exudate was present in addition to subpleural hemorrhages. The pleura over the other surface nodes appeared unchanged. Groups of subpleural petechiae were noted at places away from them. The nodes were roundish in shape, rather firm in consistence, in general of a reddish-grey color with some yellowish-white portions.

Heart without conspicuous changes. The liver was less altered than in the preceding cases. Spleen was markedly enlarged and soft.

In smears from a lung node as well as from a congested piece of the middle lobe very numerous plague bacilli were seen. Spleen smears contained considerably fewer. Positive cultures were obtained from the lungs.

Sections from portions of the lung nodes showed the alveoli to be filled with an exudate which was partly serous and partly cellular (leucocytes preponderating) or consisted mainly of leucocytes. The interalveolar septa stained well on the whole. In addition to some contaminating bacteria many plague bacilli were noted especially where erythrocytes existed in the exudate. When leucocytes alone were present *B. pestis* were not so numerous. On the whole they seemed less plentiful than in cases of primary pneumonic plague as observed in Harbin 1921.

Changes in liver and spleen corresponded to those described above. Bacilli did not appear numerous in both organs.

Before attempting to classify the above two cases it may be well to discuss in a more general manner how far metastatic foci may occur in so-called septicemic cases.

It is often held- and it is undoubtedly true for some of the cases - that patients with 'septicemic' plague succumb before there is time for the development of marked changes. This seemed to be the explanation of our *pulmonary* cases. Philip and Hirst who observed a prevalently septicemic outbreak in Ceylon (the other cases being bubonic in nature) stated that - though large numbers of bacilli were found in the alveolar cavities of the lungs - only a few of their septicemic cases showed "a patch of consolidation but in each case pneumococci were present in large numbers in addition to the plague bacillus". It was also observed that no true pneumonic cases were met with and multiple infection among the members of a household was rare.

On the other hand, evidence exists that plague metastases may occur in cases without manifest buboes. Thus among the three above-mentioned cases of the Austrian Plague Commission, was one where a superficial pneumonic focus (size of a pigeon's egg) was found in the left upper lobe, covered by fibrin membranes. It is true that in this case secondary infection with diplococci had taken place but only a few cocci were found in the lung focus while plague bacilli abounded. The authors concluded that it showed "the macroscopic and microscopic alterations and enormous numbers of bacteria characteristic of plague pneumonia."

Crowell records the following two cases among others with so-called septicemic plague.

i. Young Filipino stated to have died after an illness of only one day. Manifest primary buboes were absent. There were "numerous cutaneous vesicles and extensive secondary plague nodules in the lungs".

ii. Chinese, 32 years old, died after more than three days' illness, showing at autopsy no manifest primary buboes. Numerous nodules, varying in size from a few millimeters to 1.5 centimeter diameter were found in the lungs. They were grey-white in color with somewhat softened centers.

No.	How obtained	Macrosc. findings	Smears	Culture	Exper.	Remarks
4	Found dead near village, Oct. 2.	Rather decomposed. No buboes. No pleural exudate. Lungs pink. Liver yellowish-grey, no nodes. Spleen not enl.	Susp.	Pos. after subcult.	Pos.	No fleas; only one louse
5	Brought dead from village, Oct. 7.	Much decomposed. No buboes or other charact. changes	"	None	None	No parasites
6	Brought dead from station godown, Oct. 8.	Subcut. tissues cong. with hemorrhages at places. Small suppurating bubo in left groin. Bilat. pleur. exud. Lungs cong. Few small nodes in liver. Spleen little changed	Susp.	Pos.	Pos.	5 fleas (4 fem., 1 male <i>X. cheopis</i>)
7	Brought alive from village Oct. 7. Killed next day	No marked changes besides sl. spleen enlarg.	Neg.	Susp.	Pos. with cult.	No parasites
8	Brought dead from station godown Oct. 10.	Hemorrh. in subcutis. ? left. ing. bubo. Hyperemic areas lung. Rest decomposed (spleen large)	Pos.	None	None	"
9	"	Decomposed. ? subcut. hemorrh. and hyperem. areas lung. Spleen large	Susp.	"	"	"
10	Found dead opposite station, Oct. ?	Subcut. tissues congest. Polyadenitis. Sl. pleural effusion. Hyperem. areas lg. One? node liver. Spleen enlarg.	"	Pos.	"	4 fleas (1 male, 2 fem: <i>X. cheopis</i> + 1 hamster flea- <i>Neopsylla bidentatiformis</i> W.
11	Found dead near station Oct. 13.	Much decomposed. ? hyperemic areas lg. Spleen large	"	None	"	No parasites

Fleas found on 2 healthy rats were as follows :

Rat No. 2 14 fem. *X. cheopis*.

Rat No. 3 1 „ „ „ + 1 fem. *Neops. bidentatif* W.

We are obliged to Dr. Joff (Rostov) who has kindly determined the hamster-flea and confirmed our finding of *X. cheopis*.

The above well observed cases suffice to prove our point. And, applying this knowledge to our two cases we have no hesitation to consider post-mortem No. 2 as belonging to the same category as Crowell's case (ii) though of a considerably less advanced stage. Our case 8 is less easy to analyse. In fact we must reserve final judgment until we have investigated it more exhaustively than was possible up to now. As far as we can see at present, however, we are inclined to consider its lung changes as secondary (metastatic) in nature.

Such cases are of great interest for various reasons. To mention but one aspect, we may refer to hitherto not definitely classified plague cases met with in French West Africa (1). Though similar in many respects to true pneumonic cases, they differed in others, notably through conspicuous involvement of the mediastinal or mesenteric glands and rather limited infectivity. Could not these atypical cases be of a septicemic rather than a true pneumonic nature?

4. Observations upon rat plague.

To obtain plague rats for laboratory investigation seemed at first a hopeless task. The villagers when asked to deliver living or dead rats on reward declared that all had disappeared early in the epidemic. A few animals fetched by some of our enterprising attendants proved quite healthy, being evidently captured well away from the infected part of the village. On October 2, however, we were fortunate enough to ourselves pick up an infected dead rat in the fields between the village and the cremation pit. Further plague animals were obtained with the help of our laboratory men and one willing railway employee. The findings in positive and suspicious rats (all *Ep. norvegicus*) may be summarised as follows :

Histological investigation of our rat-material is not yet concluded. As far as the macroscopic findings go, it would seem that the bubonic type preponderated though perhaps 'septicemic' cases were also met

with. Of special interest is rat No. 7. This rodent seemed quite healthy when kept 24 hours outside the laboratory and showed at autopsy no lesions except some spleen enlargement. Smears from this organ as well as heart and lungs were negative. Fortunately two cultures were made from the spleen. One remained sterile, while the other looked suspicious. A guinea-pig infected percutaneously with material from this on October 30, died after six days of typical plague with inguinal bubo and secondary bacteremia.

Cases like this might be easily overlooked when numerous rats are examined unless systematic inoculation of guinea-pigs with emulsions prepared from the combined organs of several rats is practised. We were on the point to resort to this procedure when we obtained positive results by researches upon individual rats.

5. *Experiments with human parasites.*

a. *Fleas (Pulex irritans).*

The possibility that, in addition to the rat-flea, human parasites (both fleas and bed-bugs) might take part in the spread of plague had been contemplated early in the present pandemic by authors like Simond (32). Actual proof for this was provided by the classical experiments of Verbitski (33). This author succeeded in infecting healthy rats not only by inoculating them with ground-up infected human fleas but also through bite of living ones; such fleas were found to "communicate the disease to healthy animals for three days after infection".

Investigations of the Indian Plague Commission showed that besides rat-fleas numerous *P. irritans* could be caught upon humans entering plague houses (34). Out of 85 human fleas caught upon tanglefoot paper (placed round the cages of test animals) and dissected, only one was found to contain plague bacilli as compared with 23 out of 77 rat-fleas (35). Experimenting with human fleas which had previously fed upon selected septicemic rats, they obtained three successful transmissions out of 38 experiments. They also showed that multiplication of plague bacilli took place in the stomach of *P. irritans*. The conclusions of the Commission were that "taking into consideration the evidence relating to the spread of infection by direct contact and further taking in account the slight septicemia as observed microscopically and by cultural methods in human cases compared with that in rats, we think that transmission of infection from man to man by means of the human flea is probably a very infrequent occurrence" (36).

Similar experiences were made in Japan (37). During an epidemic in the town Yura 4.9% infected *Pulex irritans* were found among a total of 147 in October 1908, while in November (when the percentage of infected fleas had fallen considerably) not one of the 33 human fleas was found with plague (38).

The above evidence, especially the experiences of India, suggested the human flea to be of little practical importance in the spread of plague. In due course it was asked, however, if what was true for Indian conditions must necessarily apply to other areas, especially where a temperate climate prevailed. It was considered that human parasites might have been of paramount importance in European epidemics of past centuries (Martin 39, Hylkema 49). Wilkinson (41), studying an outbreak in Liverpool in 1914, came to the conclusion "that the infection had been transmitted by human fleas from the first plague case to the others". Bacot (42) reviewing the evidence in 1919, stated that the importance of fleas like the *P. irritans* had "been rather overlooked." Lethem (43) analysing the plague outbreaks in Great Britain deduced:

- i. That in this country the first case of an epidemic is infected by a rat-flea, usually found in grain or rags;
- ii. That such cases occur rarely, because of the habits of the brown rat and *Ceratophyllus fasciatus*, common in cold climates;
- iii. That just as plague in rats is spread by rat-fleas, so is plague in man in cold climates spread by human fleas, once the disease is started;
- iv. That the sudden stoppage of the epidemics here is due to the short period for which the human fleas remain infectious."

Human fleas were also suspected to be important vectors of plague in other areas, e.g. Ceylon (44), Morocco (45), South-East Russia (46), Transbaikalia (1).

Bearing in mind all this evidence as well as the fact that all early reports ascribed infection of the various settlements to human agency, our attention was naturally focussed upon a possible rôle of human fleas in the Tungliao region. We soon obtained a splendid opportunity to investigate this problem: when visiting the notorious inn of Chien-Chia-Tien on the afternoon of September 25, (the opening day of our field laboratory), we found 8 victims there. Though they were all seriously ill, none appeared to be in a desperate condition. Especially one young man, who was able to rise and talk to us, and looked as if he had some chance of recovery. When entering the place again on the morning of September 26, the first sight which struck our eyes was this young man lying dead near the entrance. Likewise all other patients except a youth (who recovered eventually) were found dead on their *k'angs*. Even a small puppy which had shared the kitchen of the infected inn had succumbed during the night!

In a dull light we immediately started to search for human parasites in the clothes and blankets of the deceased. Though we saw about 8-10 fleas jumping about on the *k'angs*, we managed to capture four only. This ordeal lasted over one hour. Three fleas, which were big

and dark in color, were placed in one sterile test tube; the fourth, smaller and lighter, in a second. Returning to the laboratory we identified under the microscope the three first mentioned fleas as *P. irritans*. We then ground these up in physiological salt solution under sterile conditions and injected the emulsion into a healthy guinea-pig. This animal was found dead on the morning of September 25. At autopsy no marked gland involvement was found, only one inguinal gland being slightly enlarged. There was peritonitis with abundant purulent, sticky exudate. The spleen was not much enlarged, the liver was congested and the lungs free. Plague bacilli were not numerous in smears from the inguinal gland though swarming in the peritoneal exudate. Abundant typical growths were obtained from peritoneum, liver and spleen.

The fourth flea was a female *X. cheopis* as confirmed by Dr. Joff.

An opportunity for a second experiment offered itself when on the afternoon of October 5, one of our burial attendants - who though not being instructed by us still hoped to receive a reward for special service - collected two large black fleas from a dying patient (our post-mortem No. 9 with 'septicemic' plague). Since it was too late to perform experiments on the same day, the fleas were kept over night in the laboratory. Next morning (i. e. 15 hours after collection) they were identified as human fleas, emulsified and injected into a stock guinea-pig. The animal survived up to October 14 (8 days). At *post-mortem* we found a big, partly caseating left axillary bubo. Hyperemic areas were present in the lungs. Numerous nodules were noted in the liver while the moderately enlarged spleen was full of bigger nodes. Few plague bacilli (mostly involution forms) were seen in smears from bubo and spleen, none from heart or lungs. A contaminated culture was obtained from the bubo only. One guinea-pig inoculated percutaneously with material from this on October 30, died on November 4, of typical, acute plague. That the first guinea-pig survived unusually long and displayed subacute changes is possibly due to the fact that the infected fleas had been standing overnight.

The puppy found dead in the inn on September 26, showed, as expected, no evidence of plague infection. Twenty-seven fleas were collected from it and thus identified:

	Male	Female	
<i>P. irritans</i>	7	14	
<i>X. cheopis</i>	0	6	(Confirmed by Dr. Joff.)

We attempted several times to expose guinea-pigs in infected houses. Desirable as it was, we found it impracticable to let them roam about on the floor, so we enclosed them in wide-meshed wire traps and placed these at points of vantage changing the position from time. The results were as follows:

No.	How exposed	Result
1,2	From Sept. 21-Oct. 1 in deserted plague house, then in inn.	App. healthy up to the evening of Oct. 1, when they were killed by a delirious patient and eaten by dogs.
3	On Sept. 26 in inn.	Died Sept. 29, showing no fleas and no evidence of plague infection.
4	On Sept. 26 in inn.	Same as in animals No. 1 & 2.
11	Exposed in inn on Oct. 8	Died Oct. 10, showing no fleas and no plague.

It is unfortunate that in none of these animals could we obtain a definite result as they either died of some intercurrent disease or were accidentally killed. However, if infection had been particularly easy, gps. No. 1 and 2 might have succumbed to plague before they met their fate from the hands of a delirious patient after such long exposure.

Some conclusions from the above experiments may be drawn. We believe it safe to state that human fleas played a rôle in the 1928 Tungliao outbreak side by side with *X. cheopis*. It is significant that the human fleas in our first experiment were caught – as it were – red-handed and ready to transmit infection from one human to another. In other words it was conducted under almost natural as compared to artificial conditions. Also we repeatedly saw fleas – evidently *P. irritans* – jumping about from plague victims, both alive and dead.

How far each of the two flea species found was responsible for the spread of infection is difficult to gauge. Of special interest in this connection was the only plague case observed in the station area where

practically all the houses were constructed of brick. In the only mud-hut existent here, an old woman died on October 13. Her relations asserted that she was ill for years and refused to acknowledge that she had plague. They were persuaded, however, to permit a spleen puncture. We obtained positive results with smears and cultures. Since lately plague-infected rats had been observed in the station area we at first thought this case to be of rat origin. Fuller investigations, however, revealed the fact that the old woman used to visit a neighboring infected village.

b. *Bed-bugs.*

As in the case of the *P. irritans*, authors like Simond (32), Hostalrich (47), Todd (48), Philip and Hirst (44), Fox (49), Levy and McMicken (50), consider the bed-bug to be a likely vector from epidemiological considerations. That they may actually transmit plague is proved by the following laboratory observations:

- i. Hankin (51) found plague bacilli in bed-bugs from a plague hospital.
- ii. Nuttall (52) worked with *Cimex lectularius* which had been starved for two months and then fed upon septicemic plague mice, their contents afterwards being injected into healthy animals. Virulent bacilli survived for 72 but not 120 hours.
- iii. Verbitski succeeded in transmitting plague to guinea-pigs with the aid of living infected bed-bugs. He also proved "that the comparatively small percentage of plague infections transmitted through bug bites is considerably increased when the bugs were crushed on the skin of the animal bitten". He observed that "bugs which have sucked their full complement of blood do not as a rule bite again for a considerable interval, but if felt crawling upon the skin may be crushed Should they contain plague bacilli these may be inoculated through any slight abrasion existing in the neighbourhood".
- iv. Hunter (53) while finding *B. pestis* in bed-bugs asserted that these quickly disappeared.
- v. Klodnitzki and Jordanski (54) found infected bed-bugs to contain virulent bacilli up to 83 days. They think crushing of the insects more dangerous than the actual bite.
- vi. Interesting observations were made by Walker (55) in an evacuation camp where an infection through rats was out of the question and no fleas were found, while bed-bugs (*C. rotundatus*) were plentiful. Twenty-four such insects collected from different tents yielded only one infected specimen, while 6 such were found among 27 bed-bugs from an infected tent. Five bugs which had sucked a plague patient were allowed to bite a rat; the animal died of plague after 60 hours.

- vii. Balfour (56) managed to transmit plague from guinea-pig to guinea-pig with the aid of bed-bugs.
- viii. Bacot (57) established that to some bed-bugs a meal of plague blood was fatal. If the insects survived they were "capable of carrying *B. pestis* and reinfesting mice after a period of 48 days' starvation".
- xi. Cornwall and Menon (58) obtained similar results as Bacot, some of their bugs dying soon while others survived up to 38 days, yielding positive cultures after that time.

We performed one experiment with 3 bed-bugs found in the inn together with the infected *P. irritans* on Sept. 20. The biggest had probably not fed recently, while two smaller ones were full of fresh blood. All three were ground up in physiological salt solution and the resulting emulsion injected into a healthy guinea-pig. The animal died on Sept 30, of acute plague with right inguinal bubo. There was an abscess-like local infiltration which had broken through into the abdominal cavity leading to peritonitis. Many petechiae over the lungs; liver degenerated, spleen enlarged. Smears and cultures were positive.

When starting the autopsy of our Case 13 ('septicemic' plague) on October 10, we found two half-starved bed-bugs in the coat covering the chest. Since we did not propose to infect animals at the time, these insects were kept for histological purposes. This examination revealed no *B. pestis*.

c. *Body-lice.*

Two experiments [injection of guinea-pigs] with emulsions prepared from ten *Pediculi vestimentorum* collected respectively from corpse No. 9 (septicemic plague) and No. 10 [bubonic plague with secondary bacteremia] showed nothing definite, for in both instances the animals died within 48 hours without any proof of plague infection. Possibly the cold weather reigning at the time was responsible for their rapid death.

Investigations by previous observers have shown that plague can be transmitted to healthy rodents not only by means of emulsified human lice (Swellengrebel and Otten, 59; De Raadt, 60; Sukneff, 61) but also by exposure of living parasites upon test animals (Tsurumi, 62).

6. Conclusions.

a. The existence of plague was proved in the rats (*Ep. norvegicus*) of Chien-Chia-Tien. Outside of some hamster-fleas (*Neopsylla bidentatiformis*) only *X. cheopis* has been found so far to infest them.

b. Inoculation experiments with both *Pulex irritans* and bed-bugs (*Cimex lectularius*) removed from the clothes and blankets of fresh plague victims gave positive results. It is likely, therefore, that human parasites, especially fleas, played a rôle in the spread of infection in addition to *X. cheopis*.

c. The clinically suspected existence of 'septicemic' cases (i.e. those without manifest primary buboes) was confirmed by autopsies.

d. While in many dissected cases (both true bubonic and 'septicemic') some lung involvement seemed present under the microscope, two displayed more marked pneumonic features. It would appear, however, that in these also the lung foci were of a metastatic origin due to infection through the blood stream.

III. REPORT ON AN EXPEDITION INTO THE PLAGUE FOCUS OF TUNGLIAO

H. M. JETTMAR AND LIN CHIA-SWEE

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A. SHORT DESCRIPTION OF THE EXPEDITION

We started on October 26 when the bubonic plague outbreaks in this district had practically subsided, and only a few sporadic cases were present.

The headquarters of this expedition was Chien-Chia-Tien, from where different excursions started.

The first of these was a trip to Tungliao, and thence north wards to Panchiatien (October 27-28) in order to investigate the rodents.

Panchiatien is situated on the northern side of the Liao-Ho, in a north-western direction sandy steppes prevail and the number of burrows of rodents are abundant. But on account of the late season the rodents—mostly sisels, some jumping-rats (*zapus*), and gerboas—have already disappeared for some weeks from the surface of the ground for their hibernation. As our time was limited, we only dug out a few burrows in order to investigate their structure and to collect some ectoparasites.

During the first period of our stay at Chien-Chia-Tien we investigated over 30 house-mice (*Mus musculus*) which were easily found under the kaoliang (sorghum) heaps. The peasants informed us that most of these follow the harvest and migrate into the houses of the village, only reappearing in spring time.

On October 29-30 a trip to Talin was performed, as we were informed by telephone that one inhabitant of this village had fallen sick the day before our arrival, perhaps from plague. The next day this patient got well, and so we spent our time in a little excursion

into the sand dunes near Talin. We collected a large number of living sand-hamsters with parasites. We also opened numerous burrows. At the same time house flies were collected from the interior of a hut where a week ago two cases of bubonic plague had occurred. From the emulsion of these flies two house-mice were inoculated intra cutaneously, but the latter remained healthy.

On November 4 we were informed about a fresh case of suspicious plague. At the village Wenchiaowopo (about 2 miles west of Chien-Chia-Tien) a 17 years old boy was reported sick with painful left axillary bubo. Thirty-six hours before his death his finger-blood was smeared upon the surface of agar tubes. Pure cultures of *B. pestis* were obtained, each tube harboring 20-25 colonies of the plague bacilli. In the first subculture of this strain the growth on agar was very slow, and only after smearing some sterile finger-blood upon the surface of the agar, did the plague bacilli grow quickly and abundantly; in the later subcultures of this strain, which served us exclusively for all further experiments, the plague bacilli grew promptly and abundantly without any addition of human blood to the nutrient medium. We did not perform a *post-mortem* of this plague case in the region of Chien-Chia-Tien. With this culture we infected two house-mice, and two Tungliao hamsters by different methods; the animals died of typical acute bubonic or septicemic plague.

After this no more cases of plague occurred, and we were able to devote our attention to the wild rodents living in the sand dunes around Chien-Chia-Tien.

Different species of rodents were unearthed, and many burrows studied and drawn. We also made a collection of ecto parasites obtained mostly in the nests of the animals, and studied the biology of both hosts and insects. But the increasing frost of November prevented us from carrying out much digging operation. We therefore proceeded to erect pitfalls by laying small tinpots in the sand. With this method we were able to catch more sand-hamsters. Lastly, brown rats and other small rodents were investigated for plague but neither *post-mortem* examinations nor cultures from organs showed any positive results. Several dogs living in infected houses were also investigated and 20 fleas (all *Pulex irritans* and not a single *Ctenocephalus canis*) were caught from which an emulsion was made in saline solution

and injected into two guinea-pigs. All these examinations were negative.

From five convalescents, who had been attacked by bubonic plague one month previously, blood was taken from the basilic-vein and their serum investigated for agglutinating properties*.

We left the Tungliao district on Nov. 20 for Harbin, where we continued our researches in the main Laboratory during the next months.

B. OBSERVATIONS ON LOCAL WILD RODENTS

In the Tungliao district the following wild rodents were observed:

1. Manchurian Susliks (*Spermophilus manchuricus*).
2. Three-toed Gerboa or Spring-hare (*Dipodopus spec.*)
3. Jumping-mouse (*Zapus spec.*)
4. Light-cream brown hamster (*Cricetulus spec.*)
5. Dark-grey vole with short tail and a black sagittal stripe on the back (*Microtus gregalis* Pall)
6. House-mouse (*Mus musculus*)
7. Brown rat (*Epimys decumanus*)
8. Mole rate (*Syphneus aspalax*?)
9. Hares (*Lepus manchuricus* Radde?)

1. *Susliks* occur widely in this district. In August we obtained for our Museum three living specimens from Panchiatien near Tungliao. They were identical with the susliks found opposite Harbin in the dunes of the left shore of the Sungari River. We placed the animals from Tungliao and Harbin together in one cage, and no fight occurred which fact showed that they probably belonged to the same species.

When we arrived at the Tungliao district, all the susliks had already retired to their holes for hibernation. Not a single animal was caught although 30 holes were opened; nevertheless we found numerous fleas. Due to the snow-covered

*These investigations made in our Harbin Laboratory showed some interesting results: While none of the plague convalescents showed an agglutinating titer higher than 1:4 (our local Tungliao strain was used) one of our surgical out-patients used as "control" showed a serum with very high agglutinating properties (over 1:20!) against the *Bac. pestis*. This patient had never had any connection with plague, and this surprising result induced us to investigate the blood from five more non-plague patients with the positive blood as control. But no such remarkable agglutinating results were seen in any of these men.

ground, the closed holes could not be detected or identified. The uninhabited open holes were often seen, especially around the fields not far from human dwellings. Also at the burial ground of Chien-Chia-Tien, where during the first period of the epidemic many plague-corpses had been buried, we detected holes leading sometimes directly into the grave-mounds. The burrows of susliks are also abundant in the steppes northwards of Tungliao on the left shore of the Liao-Ho. These burrows consist of a long passage leading straight into the earth to the small dwelling chamber situated about one meter beneath the surface, the floor being strewn with some straw. Amid this straw some feathers, old pieces of cloth or ribbons or other waste garments of man can be frequently found. The fact that susliks like to drag pieces of human clothes into their holes may be of some interest in plague infected regions where contamination of rodents from plague infected corpses is possible. From the sleeping chamber of the susliks a short blind-alley leads on the opposite side upwards and ends in a enlarged space about $\frac{3}{4}$ meter under the surface of the ground.

2. *The Gerboa*. On November 7 we succeeded in digging out one hibernating jumping hare. During one of our daily excursions into the dune-districts near Chien-Chia-Tien we observed on the northern slope of a high sand-hill a small hole, partly filled with earth. On opening the entrance, we found the passage becoming enlarged and almost polished. At a depth of about 70 cm. after the branching off of two small channels, the main passage led to a small enlargement where the sleeping animal was situated. This spring-hare was quite cold and helpless and was regarded by our coolies as dead. However, ten minutes after this animal was placed into a box laid upon the frozen ground the limbs of the animal, particularly the fore-paws, began to vibrate and tremble; after half an hour the animal awoke completely, and was much restless in its box. During the first two days of its captivity the gerboa refused food but on the third night it began to eat considerable quantities of fruit, vegetables, and seeds, after which it felt well. During the $2\frac{1}{2}$ months of captivity it remained fat and healthy, and never again made any further attempt to hibernate. Further investigation of the hole belonging to this spring-hare showed that the dwelling chamber of the animal was situated much deeper at the end of the large corridor 2 meters below the surface of the ground. This nest chamber was furnished with soft clean hay, and entirely free from ectoparasites. It is strange that the animal had elected for its hibernation the enlargement situated so near the exit while it had at its disposal this deep clean sleeping chamber. The passages of the burrow were clean and smooth, being oval shaped and directed vertically.

This gerboa was killed with chloroform on Jan. 24. The erythrocytes of the heart blood harbored two kinds of haemoparasites:

- a. A slender variety of *Bartonella bacilliformis* in small numbers, and
- b. Plentiful *Hepatozoa*, similar in many respects to the *Hepatozoon jaculi* (Balfour) or the hepatozoon, found by one of us in the blood of many Mongolian gerboas (*Alactaga mongolica* Radde) near Urga. (See Rep. VI. N. M. Pl. Prev. Service p. 235.)

This parasite in the blood of the Tungliao dipodipus is much larger than the *Hepatozoon jaculi* or the *Hepatozoon alactagae*. When still in the erythrocytes, they assume the form of a sausage or crescent. The infected red blood-corpuscle then takes an irregularly oval-shaped form, losing most of its haemoglobin, so that it becomes invisible or is seen only as a pale shadow closely adherent to one side of the parasite.

The bigger specimens of the parasite, sometimes measuring up to two diameters of an erythrocyte (10 microns) seem to circulate in the blood serum. They show a considerable polymorphism, and thick ovoid forms as well as slightly bent biscuit forms are encountered. Sometimes some vacuole-formation and the development of crescent-like processes at the ends of the body make the parasite look like trypanosoma.

This hepatozoon has not as yet been encountered inside leucocytes.

The liver of the gerboa was much changed. The peripheral parts especially of the lobules showed advanced fatty degeneration, though the arrangement of the trabeculae around the *vena centralis* was still more or less normal. As a result a nutmeg-appearance was seen in the liver sections. The whole organ was hyperemic.

Numerous liver cells contained the parasite in its schizogonic stage leading sometimes to complete destruction of the cells. Small groups of macromerozoites were seen within vacuoles, formerly filled by swollen and later decaying liver cells. The micromerozoites of the parasite were not observed.

The interlobular veins particularly were full of these parasites. Sometimes small groups were found in the blood stream next to the walls of the blood vessels.

3. The *Jumping-mouse (Zapus)* was only seen north of Tungliao in the steppes near the village Panchiatien. The local inhabitants say that it does not inhabit the sand dunes near Chien-Chia-Tien.

In October when performing an excursion to this village some burrows belonging to the jumping-mouse were opened. One of these, from which in the early autumn one jumping-mouse had been obtained, may be briefly described here. The burrow as a whole is similar to those of *Sisels*, the passages being erectly oval. The corridors are spiral-like and lead at a depth of $\frac{3}{4}$ meter to a biggish sleeping chamber. On the opposite side of this chamber a short straight blind alley leads slightly upwards. Not a single living animal could be obtained from the open holes during our stay, although these rodents are known to occur here in large numbers. A heavy snow storm prevented us from searching more inhabited closed holes of this hibernating rodent.

4. The small cream-colored hamster (*Cricetulus spec.*) from the sand dunes of Chien-Chia-Tien and Talin. While the valley of the Liao-Ho is generally fertile, allowing the cultivation of kaoliang and other products of the soil, south of the railway there extends a sandy desert with numerous dunes and sand hills allowing some cultivation here and there between the hills. In the valleys between the hills small pools or marshes are often to be seen where wild vegetation grows

abundantly. The small hills consist of pure quicksand, and harbor numbers of small hamsters which dig their holes in the slopes of those hills. The sandy surface of this region is literally covered with footsteps of these animals.

These pretty small rodents lead exclusively a night life, and do not go out of their holes at day-time. (Also in captivity which they endure very easily, they become active only at mid-night; after sunrise they become quite drowsy.) Their burrows, built in the purest sandy area, are very large, containing many passages. The main passage leads to a rather big sleeping chamber, filled up almost entirely with a loose nest, wherein mites and fleas are found. This dwelling chamber is situated as a rule at the end of the passage in the deepest part of the burrow up to $1\frac{1}{2}$ meters from the ground while other passages branch off previously. One or two of the latter go upwards close to the surface of the ground leaving only a small bridge of sand unperforated so that the animal when disturbed in its burrow may escape by opening the last barrier of one of these alleys. The hamsters often practised this trick upon us when we opened their burrow systematically, and appeared unexpectedly elsewhere on the surface of the sand, but as they are very poor sprinters they were easily caught. The burrows have almost exclusively one exit.

This species of small hamsters breed in late autumn, and we had occasion to collect small ones about 3 weeks old. Twice we found nests with new borns, one with 4, and another with 5, which had not yet opened their eyes. These animals do not keep any stores of food in the burrows, their dwelling chamber being the only enlarged space. However, we repeatedly detected in the sand some distance from their burrows some short blind-alleys containing a few seeds. These animals are voracious and curious so that we succeeded in catching them by means of pitfalls as follows: Tall empty tins were placed deep in the ground and covered carefully with sand; then around the borders of the entrance and at the bottom of the tin some kaoliang seeds were strewn. These pitfalls were mainly erected near places where abundant traces of the animals were present. When inspecting these pitfalls the next morning the kaoliang had disappeared, and in some of the falls were found the trapped hamsters. Sometimes the animals perished from cold in the pitfalls, so that we subsequently lined the bottom of the tins with thin layers of cotton wool.

The hamster travels at night away from its hole to the fields in order to collect some food, but they have not been traced to the houses of the village of Chien-Chia-Tien.

As these animals were obtained so easily and in such abundant numbers in the plague infected district, numerous ectoparasites were collected by us for plague experiments in the Harbin Laboratory.

Although various Manchurian hamsters (as *Cricetulus furunculosis*, *Cr. triton* and *Cr. spec.* from the Mongolian border near Manchouli) harbor many *Hartonella bacilliformis* and *Trypanosomata* in their blood, the blood of 50 hamsters of this species *Cricetulus spec.* proved sterile.

5. *Small dark, grey vole. Microtus gregalis Pall.**

This rodent is characterised by a black sagittal stripe on its back and lives in the fields around Chien-Chia-Tien. It was repeatedly caught under heaps of kaoliang side by side with house-mice. It is also widely distributed among the sand dunes near Tungliao and Talin.

During our stay at Chien-Chia-Tien we succeeded in opening only one inhabited hole of this species. This burrow was in the neighborhood of those occupied by sand hamsters and was distinguished by one single entrance; within were three big stores filled with round dry seeds of some wild growing leguminosae. This burrow contained two sleeping chambers, one fresh which harbor numbers of fleas, the other being an old deserted enlargement containing decomposed hay and two old hamster carcasses.

Once a dead animal was found upon the sand in the dunes, but no signs of plague were found at the *post-mortem*, and two house-mice, inoculated with organs of this dead hamster, remained healthy. Although the corpse proved at the *post-mortem* to be already decomposed, several living agile fleas were still obtained from the fur of the frozen animal.

6. *house-mice. (Mus musculus)*, were caught during the first part of our stay at Chien-Chia-Tien under heaps of kaoliang stalks. But when the fields became cleared, the mice also disappeared, so that it was quite difficult to locate them.

The mice proved very susceptible to our fresh human strain of bubonic plague: One recently captured animal, infected intraperitoneously with one colony of the original culture obtained directly from the finger-blood of our plague patient (36 hours before death) was found dead the next morning showing early swelling of the inguinal glands, enlarged spleen, and peritonitis with an immense number of plague bacilli in all organs.

Another house-mouse infected through prick in the tail died 40 hours afterwards. At the *post-mortem* early signs of plague infection in the lymphatic glands were seen, while the inner organs did not show any striking pathological changes. Smears from the organs showed only a limited number of plague bacilli.

All house-mice caught in the fields at the end of October were free from fleas.

7. *Brown rats (Epimys decumanus)* were investigated only in limited numbers. Among ten brown rats received from plague infected houses of the village Chien-Chia-Tien, not one proved to be plague infected. The animals when received dead from the inhabitants of the village were mostly free from ectoparasites. Two dead rats harbored 8 fleas, all *Xenopsylla cheopis*! This result is rather surprising since our investigations at Harbin showed that the local rats harbor exclusively *Ceratophylli*, and in rare cases some *Ctenopsyllae*. Among more than 50 living Harbin rats not a single *Xenopsylla cheopis* was found. It might be of considerable epidemiological interest to determine the exact geographical frontier of the distribution of this ordinary, plague flea in Manchuria. (Rat fleas obtained by us at Nunkiang and at Chita also belonged exclusively to the *Ceratophylli-group*.)

*As determined by Drs. Koller and Pall.

8. *Mole sps (Syphneus aspalax Pall?)* were not seen during our stay. Their burrows as well as the characteristic hills are found in abundant numbers in the immediate neighborhood of the village. Also the cemetery near Chien-Chia-Tien, where the plague corpses were buried, is undermined by long passages of this rodent.

9. *Hares (Lepus manchuricus Radde?)* are found abundantly in the sand dunes. Every day during our excursions we encountered several specimens. Their habitat is usually among the valleys between sand-hills where rich vegetation abounds. They are hunted by wolves which are seen in large numbers even at day-time near the inhabited places and villages.

C. INVESTIGATIONS OF FLEAS AND OTHER PARASITES FOUND ON WILD RODENTS

During the expedition particular stress was laid upon the study of the ectoparasites found upon wild rodents. The late season was not quite suitable for this work. We succeeded, however, in collecting a number of fleas and mites*, mostly free-living, in the burrows of the animals.

The biology of the different kinds of fleas is not the same, depending mainly upon the behavior of their hosts. This varies according to whether the host has retired for hibernation or not.

It, therefore, seems worth while to give a separate description of the ectoparasite-fauna as found in each burrow.

1. *Fleas of the Manchurian suslik*, belonging mostly to the family *Ceratophyllus (tesquorum)* were obtained at the entrance of open non-inhabited holes in comparatively large numbers.

During the first half of November, when performing excursions into the outskirts of Chien-Chia-Tien, we examined several empty sisl-holes and noticed that with one exception (see later) the dwelling chambers were filled with old fodder and the inner corridors of the burrow free from ectoparasites, while near the exit in the sand an accumulation of fleas was often observed. This behavior of the suslik fleas, already described by one of us (H.J.) among Transbaikalian susliks near Chita some years ago, is remarkable, and it is likely that these fleas sitting in the sand at the entrance of the burrow, have been exclusively developed from larvae feeding on the decaying organic matter of the nest, after the sisl has left the burrow.

These fleas must necessarily hibernate in the sand near the exit as they have no opportunity to attack their natural host before its awaking from the hibernation

*Samples of fleas and mites have been sent to specialists in Europe and America for identification.

state, i.e. towards end of March. The only possibility for these fleas to suck blood would be an accidental short visit to the hole by some small hamster—the only non-hibernating rodent in this region,—but even this seems unlikely, as out of more than two hundred hamster fleas investigated we found not a single representative of the *Ceratophyllus*-group, while the majority of the “hibernating” sisele fleas belonged to this family.

The fact that fleas are able to starve for months and even during the whole cold season, and are not afraid of frost, has already been stated by Russian authors (see Comptes Rendus du I. congrès antipesteux de l'U.R.S.S. Saratov, 1928). It is also likely that under natural conditions fleas are able to hibernate away from their hosts.

The fleas are found only in the first 20-30 cm. of the corridor near the exit; they remain entirely quiet in small holes in the sand, but can become very agile when disturbed and jump to and fro at the approach of a warm hand.

As mentioned above, the litter of the dwelling chamber in the deserted burrow of the suslik is usually free from fleas. Only once we found a collection of 30 fleas in the sand of the corridor quite near the sleeping chamber, while the latter was almost entirely clear. It seems inexplicable why in this case the fleas were concentrated upon a limited area of the corridor near the sleeping chamber, leaving the latter free.

We have also kept these fleas alive in captivity in small test tubes filled with sand in the cold for more than $1\frac{1}{2}$ months. Finally they began to die, and were used for preparations and experiments. (The sand had not been moistened or renewed, and the conditions of life were not favorable for them.)

2. *Ectoparasites of the cream-colored sand-hamster.*

a. *Fleas.* While suslik-fleas were often found near the exits of the empty burrows, fleas of the sand-hamsters could seldom be seen at the entrance, even in the empty burrows; they were usually confined to the inner corridors, and mainly in the rubbish-heap of the sleeping chamber.

In the case of uninhabited burrows, the fleas were as a rule concentrated in the sand of the corridors near the nest, so much so that when finding fleas in the sand of burrows before we had reached the sleeping chamber, we could say that such burrows did not contain any hamster.

Inhabited burrows contained most fleas in the nest; we practiced the following technic.

If in the course of digging we reached the dwelling chamber and by means of a wooden stick could feel the soft resistance of the litter, digging with spades was at once stopped, and the last barrier of sand was carefully removed with the flat hand working from inside to outside until the whole nest was exposed. Then we removed the litter with some sand under it and put it in a tin canister provided with a well-fitting lid.

Ten of these nests were taken to Harbin and kept in our Laboratory where they were partly used for experiments. During this time both the fleas and mites remained alive.

The nests sometimes contained a large number of ectoparasites. Thus, from the first treated with chloroform, we collected 62 fleas, 40 mites, and numerous larvae of small fleas, beetles and other insects. These insects were almost all alive before treatment with chloroform, as proved afterwards by microscopical investigation. (Insects already dead some days previous to their preparation in glycerine-alcohol, show plenty of air-bubbles, and their chitin takes on a dark color.) This is interesting as the nest was kept closed for one month in the laboratory.

The second nest harbored 7 fleas and more than 200 mites. In the third nest were 30 fleas and 22 mites.

Nest No. 4 contained only one flea and some dozens of mites.

The remaining nests containing a varying number of fleas and mites were used for experiments (see later).

The last nest was enclosed in a canister ($17 \times 17 \times 25$ cm.) and left uninvestigated for 80 days.

The first month after its arrival at the Harbin Laboratory, it was kept in a store room at low temperature from $8-12^{\circ}\text{C}$. On opening it one could see numerous fleas jumping here and there as well as many ticks crawling along the hay elements. In the last 40 days (Dec. 16—January 24) the canister containing this nest stood in a cool cellar near the window, the temperature varying from 0 to 5°C .

When this nest was opened on January 24, we saw in the inner wall situated next to the window a thick layer of ice crystals, while the sand at the bottom was partly frozen, but the nest was dry.

On inspecting the litter half an hour after the nest was shifted into the warm room of the Laboratory, we were at first unable to find any organic life in it. Then, after one hour we made slight probes into the sand and succeeded in collecting from half the material forming the nest the following insects.

Four living fleas, all belonging to the genus *Neopsylla*. (Under the microscope their alimentary tract showed no blood contents. One dead *Neopsylla*; 227 living larvae of flies; Over 40 specimens of different kinds of living ticks. (The other half of the nest remained uninvestigated, and is reserved for future research).

The large number of flea larvae was remarkable. They looked quite motionless in the half-frozen litter of the nest, but in the warm air of the laboratory they became lively pushing the grains of sand with great vigor. It seems that the fleas in the nest were hibernating in the larval stage as there were only a few developed fleas, not at all corresponding in number to the excessive larvae. (4:227).

The low percentage of dead larvae showed that the animals could survive under these artificial conditions of life. Some display contents in the alimentary tract but as a rule the stomach and intestines were empty.

As the burrows harbor only one to two and in rare cases three grown-up animals (young litters excepted), one might have thought that the rodents themselves harbored in their fur a great number of fleas and mites, but this is not so.

Almost all captured sand hamsters, especially those obtained from pit falls, were entirely free from ectoparasites. Only one grown-up female, a fresh mother, harbored in its fur some mites and fleas, but this animal was captured next morning after the entrance was opened. On account of the approaching darkness of the previous evening we closed the rest of the corridor next to the nest and the short blind-alley. Next day when opening the rest of the corridor, we found three suffocated hamsters and the live mother sitting close together in the narrow blind-alley. Possibly these fleas escaping from the devastated nest and the dead ones have sought the surviving animal.

Although nests in the burrows containing living young hamsters with fur had fleas, we were not able to find such parasites in a nest occupied by four recently born furless ones.

The fleas, belonging mostly to the family *Neopsylla*, are good jumpers, one leap covering over 20 cm. distance.

b. *Mites* are very common, being present in the chaff of the nests sometimes in immense quantities. For instance, we collected from one nest over two hundred specimens, but the real number must have been two times higher, as those insects, although they are small, are rather good sprinters. One middle-sized mite, (*Genus haemogamasus*) after $2\frac{1}{2}$ months' starvation was placed upon a carpenter's rule, and seen to move 10 cm in 15 seconds. Mites are restless and run to and fro at the same speed. In unsuitable surroundings they do not feel at home and may cover considerable distances in a short time.

During our work in the Tungliao sand steppes our gloves were sometimes covered with those mites, which quickly got into the sleeves, producing upon the skin annoying itching sensations. But they soon disappeared from the clothes, and at evening time we could barely find a single specimen upon our garments.

We are indebted to Dr. H. Graf Vitzthum of Berlin, to whom we sent part of our collection for identifying these mites. They belong to 5 species:

- i. *Eulaelaps* spec.
- ii. *Haemolaelaps* spec.
- iii. *Eugamasus* spec.
- iv. *Haemogamasus* spec.
- v. *Anoetus* spec.

Of the above the minute *Deutonymphae* of *Anoetus* spec. were not observed by us. They were first noted by the specialist, who detected them sitting in numbers of 50 upon the dorsal scutum of the female *Eulaelaps*.

Dr. Vitzthum kindly informs us that all these species are still undescribed, but they belong to genera typical of the acarofauna in the underground litters of small animals.

Haemolaelaps and *Haemogamasus* are real parasites, probably also *Eulaelaps*. The others are harmless *Synoeceae*.

The haemogamasus first described by Dr. Vitzthum has been called: *Haemogamasus manchuricus*.

c. *Other Insects.* Near the entrance of the burrows of hamsters as well as sisels we repeatedly found small fleas, which occurred in moderate numbers in the nests together with their maggots and pupae.

In the nests were also found larger maggots, belonging to beetles, and a small number of developed rove-beetles; also a big kind of scarab.

Attached to some specimens of fleas of the genus *Neopsylla* were some Uropodanymphs. These were as a rule found in numbers up to 10 or even more and fixed to the chitin of the posterior and abdominal part of the flea. These are very small parasites, their square diameter measuring 1/30-1/40th of the length of their hosts. They can be easily scraped off from the surface of the flea with a glass rod.

3. *In the nest of the dark-grey vole (Microtus gregalis Pall)*, opened on November 2, similar conditions were observed, as far as the ectoparasitic fauna is concerned. More than 30 fleas, and a large number of mites were caught while the single owner of the burrow harbored a couple of fleas, and very few mites. The stores were free from parasites. The deserted sleeping chamber, where in the old chaff two decomposed corpses were found, was entirely free from fleas, but was crowded with mites.

Fleas and mites were also found on Nov. 8 upon a frozen dead vole in the sand dunes. The death of this rodent must have taken place some days ago, and in spite of the heavy storm and frost these parasites were still quite agile.

4. *Observations on the parasites of other rodents.* The empty burrows of the spring-mouse (*Zapus spec.*) show features similar to the burrows of susliks. Here also accumulations of fleas were observed near the entrance, while the deserted sleeping chamber and the inner corridors were free.

The hibernating gerboa (*Dipodopus spec.*) was not infested by ectoparasites, nor was the pure sand in the enlargement where it was hibernating. The clean sleeping chamber, situated below at the end of the blind corridors as well as the sand in the corridors, was quite free from ectoparasites.

The fleas of the brown rat (*Epimys decumanus*), all identified as *Xenopsylla cheopis*, have been mentioned already.

Strange results were obtained by us when investigating six dogs found in plague infected houses. Altogether 22 fleas were obtained from them, not one being *Ctenocephalus canis*; every one of the 22 specimens was *Pulex irritans* L., evidently from man! How far this condition was caused by the plague resulting in a scarcity of their natural human hosts in the affected homes it is difficult to say.

No lice or real ticks were found on any of the investigated wild rodents.

D. PLAGUE EXPERIMENTS WITH THE TUNGLIAO SAND-HAMSTER AND ITS ECTOPARASITES

1. *Studies on the susceptibility of the Tungliao Sand-hamster to plague.*

These small hamsters, caught in large numbers in the sand dunes near Chien-Chia-Tien, were brought in cages to the Harbin Laboratory, where many were used for plague experiments. The high susceptibility of this small wild rodent to infection is shown by the following table:

TABLE 1.
Showing plague experiments upon the *Tungliao-hamsters*

Hamster No.	Method infection	Date infect.	Date died	Days after inoc.	Ectopar. used?	P. M. findings	Bacteremia	Smears	Cultures
1	<i>Subcutan.</i> (culture used: emulsion of colony obtd. directly from finger-blood of plague pt.)	9 Nov.	11 Nov.	1 $\frac{3}{4}$	No	Oedem. hemorrh. exud. in subcutis. Spleen dark, swollen. No distinct buboes	At p. m.: erythr. to pl. bac. 500:1	Liver, spleen mod. numb. of B. P. In the edema numerous	Edema, spleen, liver, heart blood pos.
2	<i>Intracutan.</i> (rubbing the plague culture I into shaved skin of abdomen)	9 Nov.	12 Nov.	2 $\frac{3}{4}$	No	Hemorrh. edema of subcut. Spleen dark, swollen; hemorrh. in one part of small intestines	---	Numerous B. P. in spleen, liver, edema, heart blood	Edema, spleen, liver, heart blood all pos.
3	<i>Intracutan.</i> (as in No. 2)	1 Dec.	4 Dec.	2 $\frac{1}{2}$	No	Thickened subcutis, oedemat. hemorrh. exud. Spleen dark, swollen	At p. m. erythr. to B. P. 1:1	Spleen, liver, heart blood numerous	Spleen, liver pos.
4	<i>Intracutan.</i> (as in No. 3)	1 Dec.	7 Dec.	6 $\frac{3}{4}$	No	Left axill. bubo; in the abdom. subcutis: hemorrh. edema. Ingl. reg.: small glands covered with hemorrh.; liver congested; spleen enl. two times	5. Dec. no bacter. 12 hours before death still agile, beginning bacter	In all smears: plenty B. P.	Liver pos.
5	<i>Cutan.</i> (rubbing slightly plague culture upon fur and skin of abdomen)	1 Dec.	4 Dec.	2 $\frac{3}{4}$	No	Slight edema in the subcutis. of breast. Axill. glands enlarged, espec. on left side. Spleen dark, swollen	---	Axill. bubo: masses of B. P. Spleen, liver many B. P.	Liver, heart blood pos.

TABLE 1.--Continued

Hamster No.	Method infection	Date infect.	Date died	Days after inoc.	Ectopar. used?	P. M. findings	Bacteremia	Smears	Cultures
6	<i>Cutan.</i> As Hamster No. 5	1 Dec.	4 Dec.	2 $\frac{3}{4}$	No	Edema of the subcut. of abd. and breast. Beginning buboes. Small intestine edemat. with hemorrh. Mesent. glands enl. Liver, spleen congested	In heart blood more B. P. then erythr	Spleen, liver, heart masses of bac.	Liver pos.
7	(<i>Per os</i>) (plague material transferred to fur of trunk)		Remained healthy			---	7. Dec. no bac. in blood	---	---
8	(<i>Per os</i>) (as hamster No. 7)		Remained healthy			---	7. XII. no bac. in blood	---	---
9	<i>Intracutan.</i> (smearing of plague culture into shaved skin of abdomen)	8 Dec.	10 Dec.	2 (48h)	No	Edema of abdomen skin. Spleen sl. enl.; beginning buboes	---	Spleen, liver masses of B. P.	Liver pos.
10	<i>Intracutan.</i> (as in hamster No. 9)	8 Dec.	11 Dec.	2 $\frac{3}{4}$ (64h)	Yes	No P. M., as corpse was used for other purposes	Beginning bacter. 48h. after inoc.	---	---
11	<i>Intracutan.</i> (as in hamster No. 9)	8 Dec.	11 Dec.	3 $\frac{3}{4}$ (57h)	Yes	No P. M., see No. 9. Big primary axill. bubo	48h after inoc. no bacteremia; 66h beginning bact.	---	---

TABLE 1.—Continued

Hamster No.	Method infection	Date infect.	Date died	Days after inoc.	Ectopar. used?	P. M. findings	Bacteremia	Smears	Cultures
12	<i>Intracutan.</i> (as in hamster 9)	8 Dec.	10 Dec.	2½(55h)	Yes	No P. M.; see No. 9. Big primary axill. bubo	48h after inoc. severe bacteremia	---	---
13	<i>Intracutan. with mites</i> (emulsion from 5 mites of hamster 11 smeared into shaved abdomen skin)	12 Dec.	Remained healthy			---	---	---	---
14	<i>Exposed to mites</i> (10 mites collected from hamster 10 were placed upon fur)	11 Dec.	Remained healthy			---	---	---	---
15	<i>Intracutan. with flea</i> (emulsion of one flea coll. from skin of hamster 11 smeared into shaved abdomen skin)	11 Dec.	Remained healthy			---	---	---	---
16	<i>Intracutan. with flea-culture</i> (culture from emulsion of a neopsylla, coll. from hamster 11)	15 Dec.	19 Dec.	4(95½h)	Yes	Liquid, non-hemorrh. edema in subcutis of the abdomen. Local necrosis. Left axill. glands swollen. Spleen enlarged, liver kidney very congested	92h after inoc. advanced bacter. several B. P. in every field	All inner organs: masses of B. P.	Liver pos.

TABLE 1.—Continued

Hamster No.	Method infection	Date infect.	Date died	Days after inoc.	Ectopar. used?	P. M. findings	Bacteremia	Smears	Cultures
17	<i>Per os</i> (fed on plague corpse of hamster 11, Dec. 12; fed with spleen and liver of plague g.-pig Dec. 19-20)	?	22 Dec.	2-3 days	No	Spleen enl., liver swollen with necrotic loci; inflammation of duodenum, hemorrh. along the whole small intestine	Severe bac. immediately before death	Liver, spleen many B. P. Few immucus of small intest	Liver, heart pos.
18	<i>Per os</i> (placing spleen 16 into the mouth)	19 Dec.	Remained healthy						
19	<i>Per os</i> (like hamster No. 18)	19 Dec.	22 Dec.	2 $\frac{3}{4}$	No	Big submax. bubo very hemorrh.; spleen enl. Small intestine from pylorus inflamed		Masses of B. P. submax. bubo. Spleen, heart blood many B. P.	Heart, liver pos.
20	Hamsters 20-24 were <i>Inhaled</i> with an emulsion of agar culture	27 Dec.	30 Dec.	2 $\frac{1}{2}$	No	Nostrils: bloody secretion, spleen enl. Lungs: Right Upper and Middle lobe: totally involved, R. L. L. cont. air, L. U. L. totally involved, L. L. L. contains air. Central lobe pneumonic. Pleural exudate		B. P. in all smears	Liver pos.

TABLE 1.—Continued

Hamster No.	Method infection	Date infect.	Date died	Days after inoc.	Ectopar. used?	P. M. findings	Bacteremia	Smears	Cultures
21	<i>Inhaled</i> (see hamster No. 20)	27 Dec.	30 Dec.	2½	No	On one spot of stomach hem. plaque, spleen enl. liver: nutmeg appear. Lungs: R. U. L. involved; R. M. L., R. L. L. contain air; L. U. L. partially hep. L. L. L. contains air, Central L. contains air. Pleura: liquid exudate	—	B. P. in all smears	Liver pos.
22	<i>Inhaled</i> (see hamster 20)	27 Dec.	30 Dec.	3	No	Nostrils: bloody secretion, spleen sl. enl. liver: one echinococcus. Lungs: R. U. L., R. M. L. contain air, R. L. L. partially hep. L. U. L., L. L. L. partially hep. C. L. beginning hep. Pleural exs.	—	B. P. in all smears	Liver pos.
23	<i>Inhaled</i> (see hamster No. 20)	27 Dec.	31 Dec.	4¾	No	Nostrils: bloody secretion, severe emaciation. Lungs: R. U. L., R. M. L. partly contain air; R. L. L. mostly hep. L. U. L., L. L. L.: total involved Central L. involved Pleuritis fibrinosa.	—	In smears from spleen <i>no bacteria</i> seen!	Liver pos.

TABLE 1.—*Concluded*

Hamster No.	Method infection	Date infect.	Date died	Days after inoc.	Ectopar. used?	P. M. findings	Bacteremia	Smears	Cultures
24	<i>Exposed for inhalation</i> (Placed in one cage together with hamster 23, one day before death of the latter)	30 Dec.		Remained healthy					
25	<i>Intracutan.</i> (The exposed hamster No. 24 was afterwards infected by rubbing plague cult. into shaved skin of abdomen)	15 Jan. 1929	18 Jan.	2½	No	Primary left axillar. bubo, typ. ac. bubon. plague	12-16 h. before death blood still no B. P.	In all smears numerous B.P. espec. in axill. bubo	Liver pos.

The above table shows the high susceptibility of this hamster to plague infection by various methods. With the exception of the oral one, all other modes of infection showed a mortality of 100%!

The comparatively low susceptibility of the hamsters to oral infection has already been proved on the *Cricetulus furunculus* in Transbaikalia*.

Hamster 17 which partly ate up the corpse of Hamster 11 by gnawing off all the ribs and clavicles, was apparently not affected, but 6 days later when it received the spleen and liver of an infected guinea-pig, it developed signs of the disease and died of acute intestinal plague.

From the two hamsters 18 and 19, both forced to devour the spleen of the plague-infected hamster 16, only one animal died while the other survived. The most characteristic findings at the *post-mortem* of the infected animal was a large hemorrhagic gland in the submaxillary region with all the features of a primary bubo.

To the category of oral infection may be counted also hamsters 7 and 8, to whose fur on the trunk some squashed spleen of hamster 6 was applied. As these animals are neat, licking and cleansing their fur very often, it is undoubtable that the material containing immense numbers of plague bacilli was devoured in both cases.

Summarising all the cases of oral infection, we find that out of 5 hamsters thus experimented only two (40%) died of plague.

The negative experiments with mites, fed upon plague infected hamsters during the septicemic stage, and also with one flea of the genus *Neopsylla* (hamsters 13,14,15) do not necessarily prove resistance of the hamsters to this mode of infection. It seems more likely that in these cases the ectoparasites used for the experiments did not bite the hamsters during the septicemic stage of the disease, and were therefore not infected at all.

Excluding the negative cases seen in these two methods of infection, all the hamsters, experimented upon succumbed to acute plague.

*See Jettmar, Pesterfahrungen in Transbaikalien. Zeitschrift für Hygiene (1923). (4 Transbaikal hamsters which survived after intra- and subcutaneous infections, ate up while in their cages the plague carcasses of their comrades but did not develop plague.)

Hamsters 5 and 6 infected *cutaneously* died $2\frac{3}{4}$ days after being rubbed slightly upon the fur and the uninjured skin of the abdomen with an agar culture. *Hamster 5* showed enlarged axillary buboes with an immense number of plague bacilli, but no distinct changes in the intestines or mesenteric lymph nodes. It, therefore, died of primary bubonic plague the same as by intracutaneous methods.

Hamster 6 showed a gelatinous hemorrhagic edema of the subcutis with early axillary buboes as well as hemorrhages in the small intestines and enlarged mesenteric lymph glands. It is difficult to say whether we have to deal here with a primary intestinal or bubonic plague.

Nine hamsters were infected *intracutaneously* with material containing living plague bacilli (2,3,4,9,10,11,12,16 and 25). The technic was always the same: On the left side of the abdomen, between the umbilicus and the inguinal region, the fur was plucked off in tufts and the bare skin shaved with a sharp knife until slight hemorrhages appeared. Immediately afterwards the plague material (cultures, spleen or smashed flea) was rubbed into the injured skin.

The duration of illness was not equal even under the same conditions. Thus, hamster 3 died after $2\frac{1}{2}$ days of severe bacteremia with early buboes, while hamster 4 died after $6\frac{3}{4}$ days, showing at *post-mortem* big axillary buboes and a much enlarged spleen. In this animal the bacteremia appeared on the last day of illness.

The duration of illness was as a rule $2\frac{1}{2}$ –3 days, while the septicemic period lasted only 16 hours or even less, the latter developing so rapidly that in the heart blood of the corpses plague bacilli were found in large numbers.

The most interesting features at *post-mortem* were the primary buboes at the site of inoculation while inguinal buboes were missing. This axillary swelling was sometimes so large that it was visible and palpable during life through the intact skin.

Other results of the *post-mortem* were swollen spleen, edematous hemorrhagic exudate of the subcutis, and the usual hemorrhages in the inner organs encountered in primary bubonic plague. We need not dwell further upon these.

Only one animal (hamster 1) was infected subcutaneously. The course of the disease was very rapid, the animal succumbing after $1\frac{3}{4}$ days. At *post-mortem* the most striking feature was the huge edematous hemorrhagic exudate covering the subcutis of the whole abdomen

and stomach, while buboes were not seen. Plague bacilli were mostly concentrated in the subcutaneous edema, as well as in the blood and inner organs.

2. *Inhalation Experiments.*

To us it was interesting to compare the results of inhalation experiments upon small hamsters with those obtained by us three years ago upon local sisels and tarabagans (see Reports North Manchurian Plague Prevention Service 1925-26 page 1-25).

Four hamsters (20-23) were inhaled with a 49-hour old agar culture of *B. pestis* obtained from the heart blood of a subcutaneously infected hamster. From this agar tube, showing abundant growth, an emulsion in 10 cc. of bouillon was made and poured into a perolene atomizer.

The four animals were placed together in a wooden box (12½ by 7 by 12½ cm.), having at one side an aperture (2 cm. in diameter) situated at a height of 7 cm. through which the nozzle of the atomizer was introduced. The animals were below this level.

The hamsters were inhaled without disturbing them for half a minute, during which time 20 slight expressions of the atomizer were performed.*

Then the animals were left in the cages for 2 hours and afterwards transferred into separate cages. All these inhaled hamsters succumbed to *primary pneumonic plague*.

Three animals (20, 21 and 22) succumbed quickly showing complete hepatization of single lobes of the lung with septicemia. The fourth hamster (23) lived considerably longer, the agonal state lasting more than one day. This comparatively long duration of illness especially in the last stage has been repeatedly observed by us in inhaled tarabagans and susliks, when dying of true primary pneumonic plague. In this animal parts of the right lung and the whole of the left lung were fully hepatized so that the removed organ, when thrown into saline solution, was immediately submerged.

There was no marked difference in the frequency of involvement of the different lobes. The findings in each case were quite different: Sometimes the upper, sometimes the lower, lobes showed hepatization; in one case the left lung was more involved, in others the right lung, etc.

*The apparatus and the technic were on the whole similar to those employed in our inhalation experiments with tarabagans and sisels in the year 1926.

The histological changes in these inhaled lungs* are briefly described here:

Hamster 20.

a. *Non-involved right lower lobe:* The lobe consists practically of normal tissue with exception of three miliary foci. The blood of the capillaries contains numerous plague bacilli. The small foci consist of partly atelectatic alveoli, some are partly filled with blood. The hemorrhages originate from the neighboring capillaries, and contain clusters of plague bacilli. The main blood vessels of the lung contain a considerable number of plague bacilli, while the lumina of the bronchi are almost free.

b. *Involved right upper lobe:* Even under low magnification broad blue rings or stripes (of bacilli) along the blood vessels are perceptible as well as hemorrhages and hepatization of most of the alveoli. In the arterial blood *B. pestis* are not so abundant. Most of the alveoli are packed with red blood corpuscles and plague bacilli, while the leucocytes and alveolar cells are less frequent. In some areas the masses of bacteria are embedded in a pink-colored homogeneous exudate. The development of hyaline is still faint. Almost all plague bacilli show bipolar form, rods being rare. No phagocytosis. The lung veins are enclosed by thick layers of plague bacilli, which have invaded their walls. Here and there, masses of plague bacilli break into the blood stream after destruction of the muscular layer. Some veins show complete hyalinization of their thin walls and contain numerous bacteria and early thrombi in the lumen. The bigger bronchi contain blood, exudate-cells, and heaps of bacilli. The lumen of the main bronchus of the right upper lobe contains an exudate consisting of red blood corpuscles, epithelial cells, and leucocytes and crowds of bacteria. In some areas the plague bacilli are wandering through the bronchial epithelium, which was itself in a condition of maximal secretion.

Hamster 21.

a. *Left lower lobe.* Under low magnification almost two thirds of the entire lobe are hepatized, and only little corners in the upper and lower ends still contain air. Under high magnification the emphysematous parts contain small areas of atelectatic alveoli densely filled with masses of *B. pestis*. The walls of the alveoli as well as the blood vessels contain heaps of plague bacilli. Hyaline degeneration, especially around the veins passing through the emphysematous area, was observed. The bacilli preserved their normal shapes, and showed no involution forms. As a rule they were surrounded by a layer of zoogloea stained in bluish-pink color. The hepatized area contains many exudate cells causing the dark-blue color on macroscopical inspection of the preparations. Every alveolus is packed with epithelial cells, leucocytes, lymphocytes, and red blood cells as well as dense masses of bacteria. Around the lung veins layers of bacteria or broad areas of hyaline are observed. Plenty of bacteria wander

*All sections were stained after Kossel's method.

through the walls of the veins, especially near the hyalinized areas. The lumen of the main bronchus contains plenty of plague bacilli but no compact masses of exudate cells.

b. *Non-involved right lower lobe.* The whole lobe contains air, and shows atelectatic areas alternating with emphysematous ones. The main bronchus contains bacilli between various layers of the wall. There are also crowds of *B. pestis* beneath the pleura. Some veins show masses of bacilli breaking into the lumen. The lymph spaces around these can be distinctly studied since they are packed with bacilli.

Hamster 22.

Partly involved right lower lobe. The central as well as the upper parts are hepatized, while the other areas still contain air. The veins are surrounded by layers of bacteria. The bacilli in the hepatized portion seem to be more numerous than in hamsters 20 and 21. The alveoli are packed with bacilli. Numerous hemorrhages, especially beneath the pleura. The main bronchus is filled with exudate consisting almost entirely of plague bacilli. (This hamster showed in its liver one echinococcus-cyst, measuring in diameter 2.5 mm. The inner wall of the cyst as well as the parasite were free from *B. pestis*, while in the lymph spaces of the capsule immediately under the epithelium crowds of plague bacilli were seen.)

Hamster 23.

a. *Partially involved right upper lobe.* The central parts are hepatized. The alveoli situated immediately beneath the pleura are packed with bacilli. Large areas of hyaline are found around the blood vessels and bronchi. The blood vessels themselves are hyperaemic but contain only here and there isolated bacilli. The parenchyma of the lung is literally torn up by masses of bacteria and exudate cells, so that it is quite impossible to differentiate the alveolar walls from their lumen. The hyaline coats of the blood vessels are thick; bacteria do not stain within them. Even the bacteria in the alveoli do not stain readily. Sometimes the zoogloea of the bacteria undergoes hyaline degeneration. The main bronchus contains thrombus-like accumulations of badly stained bacteria, but only few red blood corpuscles, leucocytes and epithelial cells. The epithelium of the bronchus shows degeneration and desquamation.

b. *Right hepatized lower lobe.* The whole piece is involved; only near the borders small areas filled with air are seen. Hyaline rings around the blood vessels and bronchi. The tissue shows early necrosis so that the alveolar structure of the lobe is almost entirely blurred. The big aerial passages are mostly filled with thrombi of exudate consisting of plague bacilli distributed among the zoogloea. In one main vein a bacterial cluster has penetrated forming a bacterial thrombus across. The section contains masses of epithelial cells and leucocytes, forming most of the exudate while erythrocytes are scarce. Most of the exudate-cells show signs of degeneration, sometimes of an advanced character. In some parts of the section the plague bacilli stain well, in others they are pale.

c. *Left hepatized lower lobe.* As the lobe with exception of some minute spots near the border is entirely hepatized the whole section possesses a dark-blue color showing distinctly the pinkish rings of hyaline around the big blood vessels and air-passages. The main bronchi, whose epithelium shows early desquamation, are sometimes filled with plague bacilli, erythrocytes and exudate cells. Inside of the hyaline masses around the bronchi and blood vessels, plague bacilli have disappeared. The bacteria in the lung parenchyma show involution forms at some spots. Thick layers of hyaline are seen in the alveoli. In the lumen of blood vessels bacteria are rare, sometimes absent. Thus in the transverse section of a big lung artery not a single plague bacillus could be demonstrated! In the alveolar region the tissue shows in places early necrosis and formation of vacuoles in the badly stained alveolar cells.

d. *Hepatized small central lobe:* Total hepatization. The main bronchus is filled up entirely with bacterial exudate. While the parenchyma of the lung is literally covered with bacterial masses, in the lumina of the main vessels plague bacilli are rare or missing.

In these findings the scarcity of bacteria in the blood vessels of the lungs in No. 23 is significant.

The arteries of the lungs are practically free from bacilli as compared with the involved parts. Bacteremia has taken place only in the last agonal stage, when the animal lay motionless in the corner of the cage.

Although at *post-mortem* this animal showed in its main bronchi abundant exudate with considerable numbers of bacteria, it has never been observed to cough or sneeze.

The constant involvement of at least one lobe in all four inhaled hamsters, in other words, the fact that 100% of the animals was infected with primary pneumonic plague, is somewhat surprising. In our former experiments with sisels and tarabagans the majority of the animals died of septicemic plague with a comparatively low percentage (30-40%) of lung involvement. True primary pneumonic plague cases showed a longer duration of illness than the septicemic ones. Martini stated that when inhaling mice only 60% of the animals died of primary pneumonic plague while all his inhaled rabbits died of septicemia. On the other hand, guinea-pigs and rats always died of primary lobar pneumonic plague (see Martini, E. Ueber Inhalationspest der Ratten. Zeitschrift f. Hyg. u. Infkh., Bd. 38, p. 333-34, and Klin. Jahrbuch, 10 Bd). We conclude, therefore, that the lungs of these hamsters belong to the "rat type", where the resistance of the alveolar walls against the invasion of *B. pestis* into the intra-alveolar lymph spaces is much higher than in the "rabbit" (or sisel-tarabagan) type,

where as a rule the inhaled bacilli quickly penetrate the alveolar walls.

Twenty-four hours before the death of hamster 23, another healthy animal was placed in the same cage as the inhaled hamster in order to infect it by contact. (Hamster No. 24.) This animal stuck to the sick comrade improving its nest and living the whole time closely together.

Hamster 24 did not develop pneumonic plague although the conditions for infection seemed rather favorable.

To show that this animal was not resistant to plague, it was finally infected intracutaneously (as hamster No. 25, see table) and promptly succumbed to acute bubonic plague after $2\frac{1}{2}$ days.

Recapitulating the results of our inhalation experiments, it is evident that the hamsters were most susceptible to artificial plague inhalation succumbing in 100% to primary pneumonic plague but that under natural conditions this mode of infection hardly plays an important rôle, as the inhaled animals were very inert during the last stage of the disease, only breathing superficially with their noses directed towards the ground.

3. *Plague experiments with the ectoparasites of the hamster.*

Lastly some experiments dealing with plague through ectoparasites were performed. Such experiments are difficult as it is not easy to gauge the right time for exposing the rodent to its parasites. The following are the reasons:

- a. The bacteremic stage developed rapidly and death occurred too soon for the parasite to bite.
- b. The fleas in the nest seemed uneager to bite. Most of these did not attack the rodent during its whole stay in the nest.
- c. The hamster when bitten becomes nervous defending itself and often crushing its torturers.

As the hamsters, with exception of the inhaled ones, were very active until their last hour of life (in spite of the developed bacteremia) most of the parasites perished unused.

The available experiments are now described:

i. *Those performed with hamster mites were all negative*

We never succeeded in finding in the alimentary tract of these parasites any plague bacilli (although numerous histological sections were examined) and none of the cultures of crushed mites, collected from plague infected hamsters, showed plague colonies.

With an emulsion of 10 mites collected from the plague corpses of the intracutaneously infected hamsters 11 and 12 a hamster (No. 13) and a guinea-pig were infected intracutaneously but both animals remained healthy. Hamster No. 14 was treated by placing upon it 10 mites collected from hamster 10. This animal also survived.

ii. *Experiments with fleas.*

Technic: The peripheral blood of the subcutaneously infected hamster was examined every 3-4 hours. As soon as bacteremia was diagnosed, each sick animal was placed in a small canister (8 cm. in diameter), the cover containing many holes for fleas to pass through.

This box was placed in a bigger canister (17×17×25 cm.) containing the nests and parasites. The table where these experiments were performed was covered with tangle-foot paper to catch escaping fleas. After the death of the animals the exposed parasites were collected from the fur and investigated.

Out of 20 fleas thus investigated only 6 specimens were found to contain plague bacilli in their alimentary tract; the other 14 fleas were sterile.

Microscopical sections of plague-positive fleas showed big clusters of typical plague bacilli in the stomach and intestine, while in every instance the stomodeum with the proventriculus was empty and contracted. The fleas thus investigated all belonged to the genus *Neopsylla bidentatiformis* Wagn.)

These investigations show that the plague bacilli when introduced into the stomach of this kind of flea multiply very rapidly. On the other hand barricading of the proventriculus by plague clusters does not take place.

Hamster 16 was infected intracutaneously with a culture of a crushed hamster flea of the genus *Neopsylla*, collected from hamster 10. This flea, after sucking the infected animal was kept for two days in a test tube and then emulsified with a small quantity of saline solution. This emulsion was rubbed into the shaved skin of the abdomen of hamster 10.

The duration of illness in this case was rather long (95½ hours). The most characteristic features at *post-mortem* were the local necrosis of the affected abdominal skin and the hemorrhagic edema in the abdominal subcutis. An axillary bubo and a much enlarged spleen show that the spread of plague over the whole organism had developed comparatively slowly in this case.

The next experiment deals with the question whether hamster fleas, contaminated with *B. pestis*, are able to preserve the virus for long periods of time.

A small canister 8 cm. in diameter containing the intracutaneously infected hamster No. 10 was inserted into a bigger tin holding the nest. The animal was already bacteremic and died on Dec. 11, 1928, having been there for 8 hours. After removing the cadaver the nest was kept in a cool cellar near the window, the average temperature varying from 0 to 5°C. (a temperature of -2°C. being observed once).

This nest was opened on January 24, 1929, and 4 live fleas, all belonging to the genus *Neopsylla bidentatiformis*, were obtained.

These four fleas were thrown into saline solution, and identified when still alive under the microscope. They were then crushed between two sterile slides. Only cloudy masses were expressed, the stomachs being apparently free from blood.

The emulsion was next rubbed into the shaved skin of a grown-up guinea-pig; this animal was found dead on the morning of February 1.

At the *post-mortem* the following pathological changes were noted: Local necrosis and hemorrhagic edema of the abdominal subcutis; primary inguinal bubo liver and spleen spotted with numerous necrotic foci. In the lungs punctiform necroses, surrounded by hemorrhagic rings. Smears from bubo, liver and spleen showed an immense number of typical plague bacilli, while in heart-blood plague bacilli were rare. Cultures from the heart, spleen and liver were positive.

This experiment permits the following conclusions:

At least one of the four fleas succeeded in sucking the bacteremic blood of the hamster, afterwards leaving its host to return to the nest through the holes of the small canister. Thus, in the alimentary tract of the hamster flea (*Neopsylla bidentatiformis*) living *B. pestis* could be demonstrated 44 days after exposure. These infected fleas starved during the whole time, and were kept at a low temperature (sometimes below zero). The plague bacilli showed no diminution in vitality since they were able to kill a guinea-pig with acute bubonic plague 7 days by intracutaneous inoculation.

These findings correspond to the results obtained by Dr. I. Joff (see Report Russian Anti-plague Conference 1928) with fleas from rodents of South Russia. This observer managed to keep alive plague infected fleas for over 200 days.

One nest where the plague infected hamster 11 was situated was treated, after the death of the rodent, with chloroform and all the parasites were collected. Although the influence of the chloroform vapors upon the insects lasted only a short time (the canister was

immediately afterwards opened, the litter examined, and the insects thrown into sterile bouillon), the plague bacilli inside the fleas seemed to be killed by this short treatment with chloroform, as seen by the following experiment:

One flea showed in its stomach a considerable amount of recently sucked blood. After washing it repeatedly in sterile bouillon it was crushed between two sterile slides. One of the preparations was rubbed into the shaved skin of a guinea-pig and the other investigated under the microscope. The smear contained numerous bacilli, with the morphological features of *B. pestis*. All the cultures made from this material showed only single colonies of white staphylococci, but no growth of plague bacilli. The guinea-pig remained healthy.

Experiments dealing with transmission of plague upon hamsters and other rodents through fleas have not yet been performed because of the scarcity of adult living fleas.

SUMMARY AND CONCLUSIONS

1. Observations upon wild rodents and their ectoparasites obtained in the Tungliao district Nov. 1928, are described. The biology of these rodents has been studied, and a few new species of parasites have been identified.

2. With the collected material various experiments were performed with following results.

a. The high susceptibility of 26 small Tungliao-hamsters to plague by different methods of inoculation has been proved.

b. All cutaneously and intracutaneously inoculated animals succumbed to bubonic plague showing as a rule primary *axillary* buboes, while large inguinal buboes were absent.

c. Four small hamsters receiving inhalation of *B. pestis* all died of primary pneumonic plague. The histological changes in these cases are described in detail.

d. Fleas (*Neopsylla*) infesting these hamsters could experimentally transmit plague from animal to animal. *Neopsylla bidentatiformis* was found to transmit plague to a guinea-pig after 44 days after having sucked bacteremic blood.

e. Living fleas and mites of hamsters could be kept alive in nests without feeding for over two months. Also maggots of hamster fleas were able to live for months in captivity in the nest during the winter without feeding. These observations are still unfinished.

While this paper was in press we received a report of the fleas sent to Dr. K. Jordan, Tring, England, to whom we are much indebted. According to the determination of this expert, the collection contains 8 different species, four of which are new and four belong to species occurring also in South Eastern Siberia and Mongolia. The sisl flea *Ceratophyllus mongolicus* seems to hibernate at the entrance of the holes in company with other hamster fleas, but was never found in hamster burrows. The hamster fleas, *Frontopsylla jettmari*, *Neopsylla bidentatiformis*, and three new species of *Rhadinopsylla* also occur in empty holes belonging to sisels and, perhaps also springhares, most probably through the ever-migrating creme coloured sand hamster (*Cricetulus x*) which from time to time visits the empty burrows and collects near the litter these ectoparasites.

FLEAS OF WILD RODENTS AND THEIR BURROWS IN
THE TUNGLIAO DISTRICT

Collected Nov. 1928 by Dr. H. M. JETTMAR,

North Manchurian Plague Prevention Service,

Determined by Dr. K. JORDAN

Zoological Museum, Tring (Herts), England.

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|---|--|
| <p>1. <i>Tube</i>. Fleas from the entrance of zisels' burrows. (host probably <i>Spermophilus manchuricus</i>) Sand dunes near Chien-Chia-Tien. Middle of Nov. 1928.
14 specimens</p> | <p><i>Ophthalmopsylla kukushkini</i> Joff 1927. <i>Frontopsylla jettmari</i> n. sp. (numerous) <i>Ceratophyllus mongolicus</i> J. and R. (var.) <i>Neopsylla bidentatiformis</i> Wagn. 1893.</p> |
| <p>2. <i>Tube</i>. Fleas coll. from the nest of the striped grey hamster (<i>Cricetulus griseus fumatus</i>)
22 specimens</p> | <p><i>Neopsylla bidentatiformis</i> Wagn 1893
<i>Frontopsylla jettmari</i> n. sp. (numerous)
<i>Rhadinopsylla</i> n. sp.</p> |
| <p>3. <i>Tube</i>. Fleas from the sleeping chamber of the striped grey hamster (<i>Cricetulus griseus fumatus</i>) Sand dunes near Chien-Chia-Tien, Nov. 1928
9 specimens</p> | <p><i>Frontopsylla jettmari</i> n. sp. <i>Neopsylla bidentatiformis</i> Wagn. 1893</p> |
| <p>4. <i>Tube</i>. Fleas from the nest No. 3 of the creme colored sand hamster (<i>Cricetulus</i> x.) Host still undescribed.
30 specimens</p> | <p><i>Frontopsylla jettmari</i> n. sp. (numerous) <i>Neopsylla bidentatiformis</i> Wagn. <i>Rhadinopsylla</i> (three new species)</p> |
| <p>5. <i>Tube</i>. Big empty burrow, belonging to a zisel or spring hare. Sand dunes near Chien-Chia-Tien. Middle of Nov. 28
5 specimens</p> | <p><i>Frontopsylla jettmari</i> nov. spec. <i>Rhadinopsylla</i> (two new species)</p> |
| <p>6. <i>Tube</i>. Big empty burrow (zisel?) Sand dunes near Chien-Chia-Tien, Nov. 7. 1928
22 specimens</p> | <p><i>Frontopsylla jettmari</i> n. sp. (numerous) <i>Ophthalmopsylla kukushkini</i> Joff 1927 (one specimen) <i>Neopsylla bidentatiformis</i> Wagn 1893</p> |
| <p>7. <i>Tube</i>. Fleas collected from the skin and the burrow of the creme colored sand hamster (<i>Cricetulus</i> x) Sand dunes near Ta Lin. Oct. 30. 1928
21 specimens</p> | <p><i>Frontopsylla jettmari</i> n. sp. <i>Neopsylla bidentatiformis</i> Wagn. 1893 <i>Ctenophthalmus</i> spec. (Two females) <i>Rhadinopsylla</i> (Two new species)</p> |
| <p>8. <i>Tube</i>. Fleas from an empty burrow at Panchiatien near Tungliao, belonging probably to a jumping rat (<i>zapus</i>). Oct. 27
7 specimens</p> | <p><i>Ceratophyllus mongolicus</i> J. and R. 1911 (small variety as in No. 1)</p> |
| <p>9. <i>Tube</i>. Fleas collected from one nest of the creme colored sand hamster (<i>Cricetulus</i> x). Sand dunes near Chien-Chia-Tien. Middle of November 1928</p> | <p><i>Frontopsylla jettmari</i> nov. spec. <i>Neopsylla bidentatiformis</i> Wagn. 1893 <i>Rhadinopsylla</i> (3 new species)</p> |

IV. SUMMARY AND GENERAL CONCLUSIONS

WU LIEN-TEH

In summarising the experiences recorded above, I may first express my satisfaction at the progress that has been made in our knowledge of the epidemiology of plague in North China. Regarding the Tungliao region, where I worked personally with my staff, the following points may be noted:

- i. A hopeful beginning has been made with the investigation of wild rodents and their parasites though we expect to undertake further researches so as to ascertain if natural plague infection exists among these animals.
- ii. Whatever the rôle of the wild rodents may be, we can definitely assert that the local rats (*Ep. norvegicus*) suffer from plague and thus play an intervening rôle in the spread of the disease.
- iii. Somewhat to our surprise, we found all rats examined to be infested by the *Xenopsylla cheopis*, the notorious spreader of plague in India and other warm countries.
- iv. In addition, human parasites (*P. irritans* and *C. lectularius*) appeared to share in the transmission of plague in the Tungliao outbreaks.

Turning now to the practical evaluation of our findings, there is little cause for rejoicing. *Formerly*, we had to protect but a limited part of the Manchurian frontier against inroads of the tarabagan-caused plague from Transbaikalia and Outer Mongolia. And, though human cases arise almost annually in these endemic areas, the disease usually shows little tendency to spread; only on exceptional occasions did these foci constitute a real danger to our adjacent Manchurian territory. Outbreaks have been recorded in the past from Inner Mongolia, Shansi, etc., but these did not seem to be of regular occurrence.

Now, it has been proved that endemic plague exists either in a portion of Shansi proper or some adjacent districts of Inner Mongolia leading to frequent and often dangerous outbreaks. Likewise, it has

been established that plague is entrenched in or near the Tungliao district, also causing large or small epidemics almost every year. Here domestic rodents, infested by a notorious plague flea, have been found involved. In other words, while in Transbaikalia and Outer Mongolia plague could arise only when man sought the tarabagan in the fields, in the Tungliao area the deadly germ is brought into the houses by the ubiquitous rat to attack man.

It must be realised, therefore, that the fight against plague is no more a local affair limited to certain parts of North-west Manchuria, but should be undertaken along a wide front stretching from the Russian border southwards to Shansi Province. To assemble adequate forces for this campaign will be difficult. As manifold experiences have shown, the local officials and gentry, here as elsewhere, are often fatalistic in their attitude: they consider plague as a regularly recurring evil to be taken notice of only when it becomes unusually prevalent or inconvenient. And even when a campaign has been organised after much delay, the main stress is laid upon age-long methods, e.g. spraying with carbolic lotions and other strong-smelling liquids, which, though spectacular, are not only useless but apt to confer a false sense of security.

Fortunately our higher authorities have risen above this attitude. They fully share our viewpoint firstly, that outbreaks, as soon as they arise, ought to be nipped in the bud by establishing advance anti-plague posts, and secondly that any spread of the disease must be forestalled by up-to-date methods, including systematic vaccination. There is every hope that such a medical advance post will be inaugurated next summer at Tungliao, thus forming an ideal base for conducting research work and preventing any further invasions. That a similar institution be also erected at a point of vantage in Shansi is the ardent wish of every serious student of the plague situation in North China.

APPENDIX I.

THE 1917-18 SHANSI EPIDEMIC (PNEUMONIC)*

WU LIEN-TEH

The 1917-18 epidemic originated in Inner Mongolia where, according to indefinite reports, a "winter sickness" resembling pneumonic plague was present periodically. It is also stated that plague prevailed in the Ordos country and other parts of Inner Mongolia in August, 1917. Reliable records exist that pneumonic cases were seen in the vicinity of Patsebolong, Inner Mongolia, towards the end of November, 1917. This locality lies on the northern bank of the Yellow River three days' journey on horseback distant from Paotow (Paotowchen). Wu-Yuan city, lying north-east of Patsebolong, was also early invaded. From the Patsebolong district the infection travelled eastwards, evidently carried by people who fled in panic from the plague area. Paotow, an important commercial center, was definitely invaded in December; on the 23rd of this month the disease had reached Saratsi and spread from there further eastwards, following, as always, the routes of traffic. Here the epidemic extended along the important road running north of the great bend of the Yellow River through Patsebolong, Paotow and Saratsi as far as Kueihua. From this city there are roads leading to Fengchen, and Tatungfu. Infection was mainly disseminated by two classes of people:

- (a) Wool carters hauling big quantities of wool from Mongolia to the rail-head at Fengchen,
- (b) Merchants with business in the Suiyuan district, then returning to their homes in Shansi proper.

Travelling was by cart wherever the roads were suitable, otherwise this was done on foot or by animals; the early progress of the disease is accordingly estimated at 20-30 miles per day. This traffic was constant, hundreds of carters and travellers passing a given point every day. No wonder, therefore, that the disease spread eastwards slowly but steadily, reaching Kueihua, an important town with 200,000-300,000 inhabitants on January 3, then progressing towards Fengchen (9,000 population), the rail head of the line to Kalgan and Peking in 1917.

Sent out by the Central Government to combat the epidemic I reached Fengchen on January 3, 1918. Dr. Lewis of Paotingfu and Dr. Eckfelt of the Rockefeller Foundation, Peking, who had left Peking before me on December 20 in response to the telegraphic appeals of local missionaries, arrived at Fengchen on December 30. Finding that plague had not reached the city, they decided to proceed to Saratsi (200 miles distant to the west). When reaching Wulu they received the first report of plague, being informed that in the nearby village of Beita seven out of eight wool carters had died the previous week after two days'

*No detailed account of this outbreak has until now been published.

illness, while two or three local villagers showed similar symptoms. The doctors reached Kueihua on January 3, but could do no useful work there because the local governor disbelieved that plague existed and refused to stop eastward traffic from Paotow; he would not even permit the doctors to examine any cases. Thus the doctors decided to return to Fengchen and join me. On their return trip they watched the steady extension of the epidemic; the deaths in the Wulu district had increased from 7 to 40.

As soon as I arrived at Fengchen, I tried to inaugurate an adequate campaign, proposing besides anti-plague hospitals, quarantine stations, etc. three principal measures:

- (a) Closing of traffic from the west by erecting barriers at 3 points;
- (b) Control of the passenger traffic by selling tickets only to those who are given passes after medical inspection; medical officers to travel on passenger trains.
- (c) Stationing doctors at Tatungfu, Kalgan and Nankow to watch the traffic.

The authorities in Peking preferred to suspend passenger traffic on the railway altogether, and this came in force on January 9. This measure deviated the traffic from the railway line where it could be better controlled than on the roads and therefore contributed to the spread southwards into Shansi proper.

The first plague case at Fengchen at the railway station was detected on January 8 in a would-be III class passenger. A second suspicious case was found on January 10 in a tradesman who had returned from Kueihua four days previously and had died after 2 days' illness. Dr. Eckfelt who accompanied me to the house opened the abdomen and removed a big spleen for examination. The father who should have been isolated with the rest of the family was left at large and came with a mob to our living quarters in a railway car, which they nearly burnt. The local magistrate and police afforded no co-operation as they did not believe in the measures proposed by us or even in the existence of plague. The anti-plague work came to a temporary standstill and the epidemic which should have been localised prolonged its course. Illness compelled me to return to Peking, and other doctors took up the work. This is now described:

1. *Suiyuan district.*

This forms a special administrative area comprising former Mongolian territory under a Tutung (military governor) with headquarters at Suiyuan city. The present city includes Kueihuacheng.

Plague, which had early invaded the area in its course from Inner Mongolia, continued to be rampant at Wuyuan, Paotow and Saratsi which it passed. Some spread took place across the Yellow River to the south to Sianor, which was reached in middle of December. After some delay an anti-plague bureau was established by the Tutung at Suiyuan with examination stations at Wuyuan, Saratsi, Paotow, Maitan, Taikomo, etc. About February 15, Dr. S.H. Chuan arrived with a large staff from Peking to take charge and the disease was stamped out

at the end of April. It first disappeared at Kueihua and Suiyuan in the middle of March, but lasted longer at Taikomo and in the west. Wuchuan in the north and Tocheng and Molin in the south were also affected. By the end of April the whole district was reported free and the work was liquidated in the middle of May. The estimate of a thousand total cases is probably below the mark.

2. *Chahar district.*

Fengchen lies in this district. Being separated by the Great Wall on the south it does not belong to Shansi proper and has an administration of its own.

It appears that infection was repeatedly introduced into Fengchen from the west; we know of two other instances, the first concerning a group of soldiers returning from Suiyuan on January 15 and carrying the disease with them, and the second of a traveller arriving from Kueihua and succumbing on January 22. Plague spread among the soldiers at first, then among others but caused in the beginning (from the incomplete reports available) no great havoc, the total deaths recorded up to the end of January being 60. In February the epidemic seems to have become more severe and Dr. Dilley of P.U.M.C. was sent to take part in the preventive work. The disease appeared to decline in the whole district during the first half of March, though still causing small local outbreaks. Thus it was reported on March 16 that cases had again appeared at Taolinhsien, where 40 persons died. This outbreak was, however, soon suppressed and Chahar district was entirely freed by March.

3. *Shansi proper.*

From the accompanying map it can be seen that the southern portion of the Great Wall divides Shansi proper in a small northern and a large southern portion. The former was called District III and the latter District IV during 1918 anti-plague campaign. Suiyuan and Chahar are Districts I and II respectively. Near the center of District IV lies the capital city Taiyuanfu with over 100,000 inhabitants in 1918. The main routes of traffic in District III were (a) The road from Kueihua to Tatung, where it joins (b) the important "North Road" coming from Taiyuanfu, and (c) the railway which passes parallel to the northern portion of the Wall *via* Tatungfu eastwards towards Kalgan and Peking. From Taiyuanfu another railway line, called the Cheng-T'ai Railway, runs eastwards, joining the Peking-Hankow line at the station Shih Chia Chuang. The Yellow River, forming the western boundary of District IV, did not serve as a channel of traffic at the time of the 1917-18 epidemic, as it was icebound; it was well guarded to prevent passengers from crossing on foot, and no instance is known where infection came across the River.

It seems doubtful whether a cordon established early on the southern part of the Great Wall, as proposed by the Legation Health Board on January 4, or even one on the northern part, could have prevented importation of infection into Shansi proper; such cordons were established towards middle of January but—though they much reduced the number of travellers—they were unable to prevent leakages from by-paths. Moreover they were started at a time when both Districts III and IV were invaded already by the disease as can be seen from the following table.

Locality	District	Date infected	How infected
Yin Yu	III	Jan. 4	Two laborers coming from outside Wall.
Sopingfu	"	" 5	
Tatung	"	" 7	Man returned from Kueihua.
Tso Yun	"	" 8	
Shan Yin	"	" 9	Travellers from outside the Wall.
Taichou	IV	" 10	"
Hsin Hsien	"	Before " 14	"
Kuo Hsien	"	" 14	"

The only radical measure taken early was the stoppage of traffic on the railroad to Kalgan and Peking on January 9; this did not prevent the spread of infection over practically the whole of the District III but seems to have prevented any considerable spread *via* this route outside Shansi province. Kalgan apparently suffered only little. An official report dated January 30 stated that there were no cases since the opening of the anti-plague bureau on January 18.

In addition to Area III a large stretch of territory south of and parallel to the inner Wall was early infected. Thus the Shansi Plague Prevention Bureau, taking up the systematic fight against the epidemic about January 20, was confronted by the task of dealing with a large infected locality, which was specially difficult because the disease was mainly in the villages. This peculiarity seems due to different reasons:

The towns were usually surrounded by walls and could prevent access from outside, an opportunity of which many availed themselves. Another important factor lay in the merchants with business north of the Wall being mainly villagers. If these wished to return to their homes they could best do it by avoiding the larger settlements.

Besides the above difficulties there lurked the danger of a further spread of infection into the Shansi plain containing the populous capital Taiyuanfu. The Cheng-T'ai Railway might also be invaded and thus become instrumental for further inroads. The danger to Chihli province is proved by the fact that soon afterwards it was actually invaded at a point north from the railway. Considering all these dangers and the small number of medical personnel available at the beginning of the campaign it was decided to first clear up the most dangerous districts and then deal with the others. Before going into a discussion of the details of this fight it may be well to speak of the precautions taken in the uninfected areas.

a. *Taiyuanfu.*

These measures are described by Young (63) as follows:

"As soon as the plague began to spread southward inside Yen Men Kuan (the inner wall) all gates of the city were closed and travellers from the north had to undergo seven days quarantine before they were admitted. It is easy to see the

weakness of this plan—namely, that it is not possible through questioning to determine where a man has come from. The attempt was made to decide by his dialect, but this is, of course, not dependable, because a man with a South-Shansi dialect may have come directly from the infected area in the north on his way home.

Not one case of plague occurred inside Taiyuanfu nor, so far as known, within 100 li of the city, but the protection of the provincial capital was due to the cordons across the main road at Yen Men Kuan, Hsin K'ou and Shih Ling Kuan, and to a knowledge of the exact location of all the infection in the hsiens (districts) to the north, rather than to measures taken locally. The absolute isolation of a city of the size of Taiyuanfu for any considerable length of time is out of the question. The quantities of food and fuel needed are very large and so long as the nearest infection was at such distance, it seemed safe to allow people who were bringing produce from villages within 30 li (10 miles) to enter and leave after a medical examination. As the localities in all of the hsiens between Yen Men Kuan and Taiyuanfu were on the lookout for travellers and detained such as were found, and as those who were detained at the quarantine stations at Shih Ling Kuan and Hsin K'ou were not allowed to proceed south even after the quarantine period, it will be seen that there was but slight chance of men reaching the city and the region to the south."

b. *Cheng-T'ai Railway.*

The authorities wisely refrained from stopping passenger traffic on this line. To control it only four stations (Taiyuanfu, Yu T'zu, Shou Yang and Yang Ch'uan) were permitted to sell tickets and despatch passengers after medical inspection. It was difficult to find out with certainty from where these came, but "the protection lay rather in the fact that it was difficult to get along the roads without being arrested and detained in a quarantine station, and to the fact that with the possible exception of travellers, all sources of infection within four or five days' travel on the railway were known and guarded. Thus, if a man were infected inside the wall, he could scarcely travel as far as the railway before he died of the disease" (Young).

It was certainly a bold step to subject would-be travellers to mere inspection instead of proper quarantine, but as Young states—"with the safeguards already mentioned, it was better to allow travellers to go by train after medical inspection at both ends of their journey. If intending passengers were subjected to a seven day quarantine they would almost certain travel along the roads, as they could reach their destination in about the same time. The travellers along the road could not be so well controlled as on the railway, so it seemed to the railway administration and to ourselves that the methods employed offered the best solution of a difficult problem." The proof of the pudding is in the eating. So the fact that the railway is not known to have conveyed any infection to the east shows that the authorities were wise in their decision.

c. *Outline of work in the infected areas (mainly District IV).*

We have already alluded to the principal difficulty met with when fighting the plague in Shansi, namely, the spread of the disease through the villages. It is

obvious that the inhabitants of these settlements (often quite isolated in the mountains) were prejudiced against the modern doctors and their methods. On the other hand it was essential to rely upon the co-operation of the village heads and to adopt methods harmonious with the prejudices of the people so as not to incite their resistance. This is the reason why the measures taken in Shansi were in certain respects different from those adopted in the towns affected by the 1910-11 Manchurian epidemic. Among other things no autopsies were performed as the early experience at Fengchen had shown that this might seriously interfere with the work. Every attempt was made to dispel the general distrust by the issuing of proclamations, distribution of pamphlets, oral explanations, etc. In cities the purposes of the campaign were defined to both officials and local gentry. Here it was often easy to overcome the prejudices and to enlist co-operation; in fact not a few cities took the initiative and protected themselves by closing the gates. Even in the villages the seed of knowledge fell sometimes upon fertile ground. Thus in one Shao Hsien settlement of District III people themselves stamped out the disease by following instructions mentioned in pamphlets they had received.

Amidst the calamity of the epidemic the province was fortunate to have as its Governor Yen Hsi Shan, a leader who believed in the efficacy of modern anti-plague methods and constantly impressed upon his subordinates the necessity of heeding the advice of the trained workers. He entrusted the direction of the Plague Prevention Bureau to the Chief of the Provincial Police, Nan Kuei-hsin, who was specially suited for this post on account of his executive ability and his position as head of the whole police force. This Director was assisted by an executive committee, and Dr. C.W. Young acted as Chief Medical advisor and supervisor of the field staff. As the province had postal and commercial telegraph lines as well as an extensive system of military telephones, it was easy for the head of the field staff to be in constant touch with individual working parties and thus co-ordinate their operations.

In each district (hsien) the magistrate (Chihshih) was responsible for the work, his task being, however, limited to seeing that the trained workers in charge were unhampered in their activities and to lending them his authority and assistance. On the whole these magistrates fulfilled their duties well; when difficulties were met with, the central authorities interfered with energy.

The small number of medical men available at the start of the campaign necessarily restricted their distribution throughout the areas tackled. As a rule not more than one doctor could be sent to each hsien, sometimes a missionary volunteering in the campaign. Their headquarters were usually established in the hsien city from whence they daily visited the affected localities. In exceptional cases, e.g. in Shen Ch'ih, where travelling was difficult and the plague had broken out seriously both in the city and three widely separated places, more than one party was sent to a district.

As discussed already, the big towns suffered comparatively little. In fact only three or four hsien cities were invaded by the disease so that as a rule the

work in the towns was of a purely preventive character. This included: (a) educational campaign, (b) closing of the city gates, with proper provisioning of the inhabitants, (c) inspection by police and volunteers, (d) establishment of quarantine stations for stray travellers.

In the villages the heads of the community were made responsible for reporting all cases of illness or death. The thoroughness and rapidity with which this was done depended in the first line upon the amount of pressure exerted by the district magistrate.

The district police and special workers visited the villages periodically. If the village heads were found unreliable or reluctant, they were warned or fined. As a rule the prejudices were overcome without resorting to the aid of the military; in not a few villages the people themselves were anxious to carry out the quarantine measures recommended to them or even devised adequate means by refusing admissions to strangers and persons suspected to have come from infected compounds.

A further important link in the anti-plague organisation was the institution of *wei yuans*, i.e. lay inspectors who were sent to the *hsien* by the Plague Prevention Bureau to assist the magistrate and field staff in the anti-plague work and were responsible to the head of the district field staff. These men were either graduates of the Police School at Taiyuanfu or otherwise fitted for their work; all received special training before setting out. They rendered great help in inspecting, tracing returned travellers, superintending burials, seeing that courts were actually isolated and, in many cases, remaining in infected villages until the plague was stamped out.

Sometimes isolation stations were established in the village temples or in other suitable buildings. As a rule, however, no attempt was made to insist upon isolation measures in the villages. Fortunately most of the compounds were surrounded by a wall and comprised several buildings so that the patients and their attendants, who were instructed to carry masks, could be efficiently isolated. The contacts were not permitted to leave the compound, all necessary supplies being deposited at the door or handed in over a wall or through a window. If possible the house was watched by the police but main stress was laid upon telling the healthy inhabitants to keep away from the infected compounds.

Though it was realised that cremation was best for disposing of the corpses of pneumonic plague victims, this could only be practised under exceptional circumstances. In most localities the dead bodies were buried by specially trained squads whose members were equipped with gowns and masks. If possible coffins were used containing lime. Wherever feasible the graves were dug eight feet deep. Bodies which had been improperly buried before arrival of the trained staff were duly attended to. No burning of infected premises was undertaken. Disinfection with sulphur fumes was sometimes carried out, though as a rule the houses could not be properly sealed up. Whenever the doctors had a free hand, lime was scattered upon the floor, *k'angs*, etc., especially upon visibly contaminated spots.

Then the house was closed and sealed for a period of three months at least. Young admits that they perhaps erred on the right side, making the time too long. At least it was observed here as in other outbreaks that families who "occupied the same buildings, even including the room and bed where patients died of plague", remained well. The disinfecting operations were carried out by the sanitary detachments who performed the burials as well. Experience showed that a body of ten men under a head-man was sufficient for an affected settlement. They were housed in a temple or some other convenient building. No member of the squads who had been trained and directed by fully qualified doctors contracted infection.

It is obvious that an elaborate organisation as that outlined above could not be created at once. As a matter of fact, when the work was started only two doctors were available for fieldwork in the District IV which was first taken in hand. At the close of the campaign there were in this district 13 physicians, 15 foreign lay assistants, four Chinese medical assistants and eight trained nurses.

d. *District IV.*

Work could not be started in the whole of this area at once. At first the infection was attacked at Tai Hsien and Hsin Hsien. As soon as more workers were available an inspection was made in the districts between the "North Road" and the border of Chihli province, and measures were inaugurated in the Ting Hsiang and Wu T'ai districts. In Wu T'ai Hsien only one village was found infected; in both districts the spread of the disease was checked within a few days. From Wu T'ai Hsien the inspectors proceeded along the road to Fan Szu Hsien in the north several villages on that road were found infected and work was accordingly begun in Fan Szu Hsien. Kuo Hsien (between Hsin and Tai districts) was also taken in hand, so that the whole area along and east of the "North Road" was under control. Then the districts farther west (Shen Ch'ih, Wu Chai, Ting Wu, P'ien Kuan and K'o Lan) were tackled with the idea of stamping out the disease gradually in a north-western direction. The plans had to be somewhat modified because a center of infection appeared in and around Feng Ts'un, 45 li south-west of Hsin Hsien, i.e. nearer to Taiyuanfu than any other focus. Just as the infection in Wu Chai and Shen Ch'ih (the worst infected district south of the inner Wall) was cleared up, plague appeared suddenly south of Taiyuanfu around Fen Shui Ling in Wu Hsiang Hsien, being imported by a traveller and his donkey driver. This focus was liquidated within a few days and on March 16 it was possible to say that the District IV was clean.

e. *District III.*

Here a campaign had been started early in January under the medical leadership of Dr. Chen Sze-Pang. Good results were obtained at Tatungfu city. This was divided into four districts; house-to-house inspection was carried out; quarantine stations and an isolation hospital were established. 134 plague cases were recorded in this city of 20,000 inhabitants, the outbreak declining about middle of March. In the districts the mortality was also not high but in some of them the disease continued to exist though not very actively. It appears that in many

instances the people themselves took precautions, following either the instructions they had received or evolving crude measures of their own. On the other hand they were much opposed to the modern-trained staff. Part of their resentment was perhaps due to the stoppage of passenger traffic on the railway to Kalgan, which remained in force until March 15, though freight and goods restrictions were removed in February.

When the Shansi Plague Prevention Bureau took over the responsibility for the district on March 3, it was resolved :

i. To start the work gradually, beginning with the hsiens immediately north of the Southern wall.

ii. To forbid traffic across the Southern wall even after quarantine of the traveller, as it was feared "that with the small force available and the danger that large numbers of travellers would be attracted to the quarantine stations; the reinfection of Districts IV was likely. This movement from the uncleared northern part of District III across the hsiens which would be first attacked would also tend to re-infect those cleared."

When District III was visited by the field parties on March 10, they found Shuo and Shan Hsiens free from plague. The staff was then divided into three groups. To the western one was assigned P'ing Lu, Yiu Yu and Tso Yu Hsiens; to the central one Huai Jen, Tatung Hsien except Tatung city (which retained its own organisation), Yang Kao and T'ien Chen districts; and to the eastern party Yang, Hun Yuan, Kuang Ling and Ling Ch'in Hsiens. Each group consisted of an advance detachment acting as scouts and a main party, and had at least one fully qualified medical man and the necessary auxiliary personnel. Preceding the detachment went an advance field agent (Col. Chao) who was a great help in dispelling the distrust of the people.

As anticipated, little opposition was encountered near the inner wall, but conditions became more difficult towards north, especially north-east. Nevertheless it was possible to stamp out the remnants of infection within a month and on April 15 the closing of the bureau could be recommended.

The following table shows the mortality in the two districts :

DISTRICT III.

	Total	Males	Females	Sex not reported
Yin Yu	336	76	38	222
Ying	226	142	78	6
Shan Yin	171	83	48	40
Tso Yun	165	96	35	34
Tatung	134	107	23	4
Shuo	108	19	7	82
Ping Lu	65	12	1	52
Huai Jen	62	37	25	—
Hun Yuan	52	—	—	52
Tien Chen	40	20	10	10
Kuang Ling	20	—	—	20
Ling Chin	18	8	6	4
Yang Kao	1	1	—	—
	1398	601	291	526

DISTRICT IV.

	Total	Males	Femals	Sex not reported
Shen Chih	340	175	73	92
Ho Chu	114	75	37	2
Tai	91	60	16	15
Kuo	88	50	35	3
Fan Szu	75	36	12	27
Hsin	69	41	25	3
Wu Chai	65	31	24	10
Pien Kuan	45	6	5	34
Ting Hsiang	26	7	10	9
Ning Wu	25	18	7	—
Wu Hsiang	23	13	10	—
Ko Lan	18	14	2	2
Wu Tai	4	4	—	—
	983	530	256	197

4. Chihli Province.

As can be seen from our map Chihli Province borders immediately on Shansi and thus there was great danger of the infection entering the former, not so much *via* the railway line from Taiyuanfu (where precautions had been taken) as at some point further northwards where the disease was actually present. Precautions were therefore taken in Chihli. The Legation Health Board in Peking recommended early in January that a cordon should be placed on the road leading along the Hu-Tao River, but the program was restricted to inspection in the threatened localities. Infection apparently entered Chihli *via* the Hu-Tao route, as the first cases were reported at Pai-lien in the Pingshan district on January 30. Later on the presence of the disease was noted also at Tingchao on the Peking-Hankow line (Feb. 5) and at Tushanp'u in Yanghsien. Medical detachments were sent in all three districts to suppress the plague. The Peking-Hankow line had early adopted a far-reaching program of measures. This included stoppage of traffic on the branch line to Liang-ko-chuang, engagement of additional medical men, establishment of a quarantine station at Shih-chia-chuang. Here intending passengers were detained for four days, the same policy being adopted in regard to passengers coming *via* the Cheng-T'ai Railway. To prevent passengers evading examination at Shih Chia Chuang, all small stations were closed and strict inspection was enforced at the large stations. Inspection was also carried out on passenger trains. For this purpose every train had a hospital car with two sections—the front for the patients and the rear for the medical staff. Next to this were one or more inspection cars. All new passengers had to board the inspection car first. Any cases or suspects were sent to the hospital car, the others to the regular coaches. The inspection was finished before the next station was reached so that the inspection car was again available for the new passengers. When plague actually

reached the line, a long section was closed to local passenger traffic. By these efforts it was possible to localise and to suppress the epidemic in the affected districts. Details as to the time the epidemic lasted and the number of victims are not known.

As it was feared that—as in 1910-11—plague might invade Peking, strict precautions were taken in the capital including the establishment of four anti-plague bureaux in the city and of sub-offices in the vicinity. On March 16 two suspicious deaths were reported from Tungchow District. Their contacts were immediately isolated and doctors sent out to examine the dead bodies. One was declared suspicious, the other negative. The contacts all remained well and were released after seven days' quarantine.

The 1917-18 epidemic showed some remarkable long distance sprints reaching as far south as Pengpu (800 miles from Suiyuan) and Nanking (1,100 miles). We have to deal with the localities reached by these.

5. *Fengyang, Anhwei Province.*

The Tientsin-Pukow Railway reported that at the important station of Fengyang a man was found infected with plague and died on February 5. The contacts were sent to the hospital at Pengpu where they developed plague in their turn. The authorities, assisted by Dr. Cochrane, took stringent measures including the establishment of isolation stations, while the railway adopted precautions to control the traffic. The local outbreak was soon suppressed, no fresh cases being reported after February 19. As will be seen, however, plague was imported from this area into Shantung Province and later on into Nanking.

6. *Shantung Province.*

Here the first case recorded was in a railway policeman who had returned on February 9, from the south to Tsinan. He slept in a room with three other policemen, two of whom became ill and were sent to their homes. One of these went to a village north of the Railway station, where he died on February 15, after infecting his wife and another contact; the wife died on February 26 (?). The other policeman went to his home in the north-eastern part of the city where he died on February 18, after infecting four persons in the crowded court-yard where he lived; two of his contacts, dying on February 24, were the first cases which were properly reported and bacteriologically confirmed.

Two other foci can be traced back to this case :

a. A barber who had been called in to dress the hair of the dying policeman became infected and died on February 24, at his home in Hsin-chuang (west of the city), passing the infection to three members of his family. These four cases were reported on March 2, when they had been buried already. Some of the corpses were exhumed and specimens secured which proved positive. Their contacts were taken to the Isolation Hospital established in the meantime; one more case developed among them and died on March 6.

b. A man living in the same court-yard as the policeman ran away, and took refuge with a friend living in a neighboring street. He died on March 1, infecting his friend and three others. This focus was reported on March 9, by members of the Inspection Corps recruited from students of the Medical School. The contacts were removed to the Isolation Hospital; where one died on March 15. This was the last case, the total reaching 16. Preventive measures were taken by the local authorities with the assistance of some missionary doctors. The program comprised establishment of an isolation hospital in a large compound lent by the Chinese Red Cross and house-to-house inspection which was carried out first by the police and then by a special detachment of medical students. The Shantung Railway, then under Japanese control, suspended all east-bound passenger traffic west of Changsintien from February 26, while the Tientsin-Pukow Railway did not sell tickets at the stations between Tehchow and Taianfu. Normal traffic was resumed in middle of March.

7. *Nanking.*

Nanking, lying south of the Yang-tze-kiang opposite Pukow, was exposed to infection from the Fengyang district and precautions were accordingly undertaken. On February 25 a suspicious death was reported in the city. Further cases followed, but thanks mainly to the mild weather prevailing the number of victims recorded up to the end of March was under 20. In addition to the usual measures the Shanghai-Nanking Railway issued no tickets at Ningchen. The Tientsin-Pukow line did the same at all stations between Pukow and Wuyi. The traffic on steamers was stopped as well. It must be emphasized, however, that this stoppage of the normal means of communication was instrumental in deviating traffic into other channels, launches and later on boats being used. A reporter drew attention to this fact and said that people might easily revert to traffic by road to which they had been used less than two decades ago, adding that "this has no bearing on the present plague situation which, as we all believe, is happily passed. But it may be well to make a note of it for reference in any similar contingency in the future."

This aspect is certainly very important. One cannot help feeling that the control of traffic as practised during certain phases of the 1917-18 epidemic and the early closing of many towns played an important part in diverting the disease to the villages. The attempt to protect big cities perhaps reduced the *absolute* number of victims. But while appreciating this we must not forget the sufferings of the small villages which were often left with no medical advice or relief.

Concluding Remarks.

Because of the vast territory involved during the 1917-18 epidemic, which was mainly of a rural character, few detailed statistics were collected in the individual areas.

A fair estimate places the total mortality at 16,000. We have no information of any bubonic case, but 'septicemic ones' (probably identical to our 'pulmonary' cases in Manchuria) were observed; this type succumbed before any manifest pneumonic signs developed.

The incidence among females was considerably higher than in the 1910-11 epidemic, since the latter attacked a floating population, while the Shansi outbreak affected mainly domestic homes in the villages. The mortality among the sanitary staff was low, eight native practitioners and two burial coolies being attacked altogether. Among the 16,000 estimated cases, only one recovery (in a woman) took place (63).

APPENDIX 2.

A BRIEF HISTORICAL REVIEW OF THE PLAGUE IN THE TUNGLIAO DISTRICT

LI TE-CHUAN, CHIEF MEDICAL OFFICER OF THE SSU-TAO RAILWAY

The present plague at Chien-Chia-Tien may be traced back as far as 1924. On June 20 of that year I was requested by Magistrate Li of the Tungliao District to take measures against an epidemic in the district. With one colleague and a dispenser I proceeded to Fuchiatun, a locality 50 li (17 E. miles) distant from Tungliao City. There we were told that a month ago many deaths had occurred at and near Hsiao-lao-pao. The symptoms complained by the sick were said to have been headache, glandular swellings (buboes) and sometimes diarrhoea. It was impossible to make investigations owing to the presence of bandits.

On July 13, 1925, news were received after one month's delay regarding a sickness with severe mortality at Hsiao-lao-pao and north of that place. Buboes in the groin or in the axillary region were stated to have been present, the affected persons dying after an illness of 1-2 days. When I made further enquiries at Tungliao, the report was denied.

In 1926, while cholera was prevalent at Shanghai, the presence of an epidemic was alleged at a place called Nei-Mu-Ko-La, north-west of Tungliao, the sick suffering from fever, headache and dying within one or two days. Since no official report was received from the Magistrate, the place was not visited.

On September 20, 1927, I was informed that again an epidemic was prevalent in the country north-west of Tungliao. I proceeded thither at once to study the outbreak and learned the following:

On his way back to Mongolia the Living Buddha was welcomed by thousands of Lamas coming down to Tungliao from Inner and Outer Mongolia. Evidently plague was imported by them. Twenty deaths occurred among Mongols at the Tangol Temple (north of Tungliao). At U-luan-hua, a village in the Nei-Mu-Ko-La territory, a hundred deaths were estimated to have occurred; the family Sun consisting of six members were wiped out; in another family (Hwang Hsiao-Wen) 13 out of 14 died. The principal symptoms of illness were headache, delirium and blood-

spitting. To the west of Tungliao near Tulaoyintze the so-called 'headache-epidemic' caused 30-40 deaths. Among them 8 members of a family succumbed, the ninth escaping to Tungliao City. Being ill he was sent back from there and died on the return journey.

To east of Tungliao, at a place called Hsiaolaopaoyintze (situated 20 li north of Chien-Chia-Tien) 30 deaths preceded by headache or blood spitting were reported. Three remaining members of a family of 12 escaped. But before they could reach Chien-Chien-Tien they all fell down never to awaken. Chien-Chia-Tien was not infected, as no new case had developed since. The station master of Talin reported that 50 li north of the station many suspicious deaths occurred at a village called Hulagol Temple. All healthy persons sought refuge in other settlements.

On October 2, 1927, I hired a native cart for a trip northwards from Tungliao and arrived at Maliyintzu. No patients were found here, but another village U-luan-hua, 10 li to the north, was said to have been visited by the headache-epidemic; it was free now. Because I had to return on the same day to Tungliao, I could not visit the last mentioned locality. Two or three days after my return two Japanese doctors Nishimura and Kodama went to Nei-Mu-Ku-La. Just outside the village Maliyintzu they found the dead body of Liu Hsiang-Chiu. The deceased had come from U-luan-hua. Autopsy was performed at the road-side and yielded the following results: The outer appearance of the dead body was normal. The gastro-intestinal tract contained plenty of mucus, but was found to be free from cholera bacilli. Both lungs were markedly congested and contained numerous plague bacilli. Pneumonic plague was therefore diagnosed.

On October 9, I went with Dr. Yuan of Mukden again to Maliyintzu to study the problem. The local Police Chief reported to us briefly as follows:

Seven days ago a traveller called Liu Hsiang-Chiu, aet. 41, came from Yaowopo and stayed overnight at an inn called Wanchiatien. The next morning he left the inn but died shortly afterwards on the road, his symptoms having been headache, dyspnoea, blood spitting and mild diarrhoea. No fresh case had occurred since. This statement was confirmed by the owner of the inn. We then proceeded north and arrived at Yaowopo. A recovering patient named Sun Shou-Fang told us that he lived with 35 people in a family. Ten died and the rest escaped. He himself felt ill but escaped to Chien-Chia-Tien where he smoked a big dose of opium. Later he arrived by train at Chengchiatun. Here he smoked more opium and recovered. He resolved to return and resume his work. Another patient was reported to have escaped from a family, all 13 other members of which had died. He himself fell ill and complained of suspicious symptoms such as headache, general malaise, bubo, etc.; no blood spitting or diarrhoea. He died ultimately.

On August 10, 1928, an epidemic was reported at Maliyintzu and Nei-Mu-Ku-La. Symptoms: fever and 2 days headache. I immediately sent Dr. Keng of our Tungliao Railway Hospital to investigate. Arrived at Maliyintze he found no patient. He was informed that at Nei-Mu-Ku-La there had been an outbreak of the 'headache epidemic' several days ago.

On September 1, we were shocked by a telegram reporting that 14 or 15 deaths had occurred within two or three days at Chien-Chia-Tien, the symptoms being headache and buboes. The duration of illness was said to be one or two days. Dr. Keng was sent again to report. He saw one sick with bloodshot eyes and unconsciousness who had complained of a tight feeling in the chest; diarrhoea and blood spitting were absent. On receiving Dr. Keng's report, I immediately proceeded to Chien-Chia-Tien with our Dr. Wang, but no fresh case was found available. I presumed, however, that bubonic plague might be present.

On September 6, Dr. Chun of the Plague Prevention Service, Harbin, arrived in the morning at Ssuningkai. Dr. Ch'in and myself accompanied him to Chien-Chia-Tien in the same afternoon. It is due to this trip that we could attain a definite diagnosis. We were fortunate enough to find the corpse of a man Li Hui-Hui (Mahomedan physician) who had died a few hours previously and had an inguinal bubo. Dr. Chun performed gland puncture. Smears were then made and many plague bacilli were found. Thus the mysterious disease of the last few years is definitely diagnosed. Dr. Chun is really to be congratulated for his expert co-operation. Summarising the above one must consider, if not all, many of the cases observed during the last five years in the Tungliao district as true plague.

From August 28 to October 1, 1928, deaths at Chien-Chia-Tien totalled 312. Kao-Chia-wopo, a village 20 li north-west of Chien-Chia-Tien, had the plague first and 20 or more died. An old woman with sick children escaped to the east street of Chien-Chia-Tien. The children all died of plague and the old woman succumbed also on her way back to the northern bank of River. It was due to this importation that the eastern part of Chien-Chia-Tien suffered so much from the disease. During the days following August 28, more than 20 people died. The people were panic-stricken and fled therefore to the neighboring villages or towns, such as U-luan-hua, Chen-tao-wopo, Wutaomutze, Talin, Tungliao, Chengchiatun Junction, Pamiencheng, etc. 9 deaths occurred at Tungliao, 6 at Talin, 1 at Chengchiatun, 1 at Pamiencheng. The probable center of plague is somewhat north of Chien-Chia-Tien at Haochinkola near Sanlin station of the Ssuningkai-Taonan Railway. Twenty-two cases and numerous deaths were reported at Hutaolargol.

The above is a brief account of the plague up to October 1, 1928.

APPENDIX 3.

PLAGUE INVESTIGATIONS AT TUNGLIAO, 1928

WU LIEN-TEH

For several days towards the end of July and beginning of August, Chinese and Japanese newspapers had published alarming accounts of Pneumonic Plague having occurred in the Tungliao (Payintala in Mongolian) district of Fengtien Province, where one village was supposed to have lost 20 persons and another (north of the

River Liao) practically all 60 families except three children. On August 15, the Health Section of the League of Nations wired me for confirmation, and on August 18, another telegram arrived from the Eastern Bureau at Singapore asking for details. I decided to investigate the matter myself and therefore left Harbin by the night train on August 18, changed into South Manchurian express at eight the next morning and arrived at Ssupingkai two hours later. Here I stayed for the day making enquiries from the medical and lay staff of the Ssupingkai-Tungliao Railway, whose headquarters are situated in this city. At 7 a.m. on the 20th, I started again by train and reached Tungliao station at 2 o'clock the same afternoon. The country everywhere is flat and suitable for cultivation. The district engineer Mr. Siao kindly put me up at his house since no hotel accommodation was available.

Tungliao is a newly opened-up flat area of Fengtien Province with Mr. Chi as Magistrate under the *Taoyin* (Superintendent of Circuit) who resides at Chengchiatun. The town itself is quite unimposing, a straight loose earthen road lined with grey brick houses proceeding direct from the up-to-date station. At right angles to this main thoroughfare are intersecting roads, all non-metalled because of the absence of granite in the vicinity. The total population is under 20,000 consisting principally of immigrants from Shantung, Chihli and the Liao district of Fengtien. Their occupation is mostly agricultural, some business being done in horses, cattle and clothing with Mongol tribes across the River Liao in the north. The crops grown consist mainly of beans, kaoliang, wheat, millet, and hemp. The soil is fertile and water sufficient for most purposes.

I interviewed the Magistrate, head of police and local railway staff, who acknowledged having heard of suspicious deaths in one or two villages 10-15 miles away, but the symptoms were vague and might have been due to mushroom-poisoning, influenza, meningitis or enteritis as well as plague. There was a young Korean doctor Li, who was positive about having seen a plague case with cough last year. Dr. Cheng, an observant and experienced practitioner, who had worked in Harbin in the 1921 epidemic informed me that early in August four patients coming successively from one compound in a neighboring village consulted him at his office. They said that three others living with them had died of high fever and unconsciousness; one complained of a bubo in the right groin.

The four patients seen by Dr. Cheng were as follows:

1. F. 46. with fever, cough, diarrhoea and vomiting. Died 2 days after.
2. M. 40. with fever, headache and delirium, no cough. Died next day.
3. F. 24. with fever and vomiting. Died 2 days after.
4. M. 52. with T. 102, rigor, backache, died suddenly.

He made no blood examination during life or after death, although the rapid deaths were significant.

The police could not give any definite information, and although I stayed in the city for four days I did not see or hear of any suspicious case.

In the meantime, I tried to collect some rodents in houses and the open fields. No rats were caught. Of the wild rodents, apparently the country from Tungliao

eastwards as far as Tahan (60 miles away) is inhabited by the *spermophilus*, jumping here (*Zapus*) and small mice, whose different burrows can be clearly seen from the train. I caught samples of the two former species (seven in number), but none showed any sign of disease. The *Arctomys* (tarabagan or large Siberian marmot) certainly does not exist for hundreds of miles around. Roughly the boundaries of its habitat are:

- North* Great Siberian forest known as Taiga, through which pass at one stage or another the River Shilka, Argun, Unda and Onon.
- South* Gobi Desert, where the deep sand dunes are unfavorable for tarabagans. Some parts have not been traced.
- East* Khingan Range of mountains. The Chinese Eastern Railway traverses this region.
- West* Rather indefinite, but probably extends to over 200 miles west of Urga. In the neighborhood of Urga the animals are very numerous.

Outer Mongolia with Urga as a center has for centuries been an endemic focus. Caravans carrying produce in the form of grain, fur, hides, clothing, fodder, etc. ply regularly between Mongolia on one hand and Kalgan (through Suiyuan), Tungliao and Taonan on the other. The increase of traffic brought about by newly opened railways, such as, Chengchiatun-Taonan-Tsitsihar, Tungliao-Chengchiatun-Ssuping-kai, Tungliao-Tahushan-Mukden, Tungliao-Yinkow, besides the regular land route from Urga to Kalgan *via* Suiyuan and Paotowchen, has all added to those potential dangers.

Our Dr. Jettmar after one year's work in the midst of Urga (1926-7) calls the Mongols taciturn and self-contained, where plague outbreaks are concerned and is convinced that there is a yearly re-currence of both epizootics and epidemics on a big or small scale. During recent years we have already recorded the following human outbreaks as having arisen from Mongolia:

- 1917-18 Shansi epidemic with 16,000 deaths. This began in Outer Mongolia, passed through Paotowchen and Suiyuan, invaded Fengchen, Tatung, Peking and even reached Nanking. Cases were mostly pneumonic.
- 1919 Localised outbreak at Lin Hsien (Shansi) with 350 deaths, principally bubonic.
- 1924 Localised outbreak at Hsing Hsien (Shansi) in Oct.-Nov.; killed nearly 800 persons, mainly bubonic.
- 1926 Limited epidemic in Chechan-Han in Outer Mongolia, definitely traced to tarabagans, involving 6 localities, lasting 5 weeks. Twenty-four cases were recorded.
- 1927 Scattered outbreak in Tungliao region, probably in the main bubonic and killing 95 persons. Lasted Aug.-Oct. From one corpse were obtained films showing *B. pestis*.

This year another explosion has taken place at Tungliao and Chien-Chia-Tien, involving up to Sept. 15, about sixty persons with buboes and septicemia, but it is

hoped that by early preventive measures and systematic vaccination among the inhabitants the epidemic will be limited to the sparsely populated regions. Unless it takes a pneumonic form, there is every hope that its spread will be stayed.

Railway connections.

Since the rapid means of communication may enhance the spread in these regions, the various operating railways may be mentioned in detail:

1. *Peking-Mukden (523 miles).* At Tahushan (between Koupangtzu and Fengtien) a branch line proceeds northwards to Tungliao, distance 156 miles. There are daily through services between Fengtien (Mukden) and Tungliao (244 miles) and also between Newchwang (Yinkow) and Tungliao (240 miles).
2. *South Manchurian, Dairen to Changchun (438 miles).* At Ssupingkai (72 miles south of Changchun) the Ssu-Tao Railway operated by Chinese runs on one hand northwards to Taonan to join the Chinese Eastern at Anangchi, and on the other westwards to Tungliao. Both branches pass the old city of Chengchiatun, where the Taoyin or superintendent of circuit resides.

It is thus seen that the Tungliao region is brought into close touch with big cities like Mukden (Fengtien), Harbin, Tsitsihar (capital of Heilungkiang), Newchwang (seaport), Dairen (main seaport of Manchuria), Tientsin and Peking. It is also in communication with the main trunks—South Manchurian, Peking-Mukden, and Chinese Eastern. We cannot be too careful in watching the progress of the infection.

Table of Railways in Manchuria

Peking-Mukden	523	miles
Dairen-Changchun	438	..
Newchwang-Tungliao	240	..
Tahushan-Tungliao	156	..
Chengchiatun-Tungliao	71	..
Ssupingkai-Tungliao	126	..
Ssupingkai-Taonan	195	..
Ssupingkai-Chengchiatun	55	..
Changchun-Harbin	150	..
Manchouli-Vladivostok	1,070	..

APPENDIX 4.

PRELIMINARY TUNGLIAO PLAGUE REPORT

J. W. H. CHUN

Dresser Wang and I left Harbin on September 5, and arrived at Ssupingkai on the morning of the 6th. At 3 p.m., Drs. Li, Ch'in and later Wang (all of the

Ssu-Tao Railway) went with us to the junction, Chengchiatun, whence we boarded a special car which was pulled to the station Chien-Chia-Tien early on the morning of the 7th. Dr. Li Te-Chuan (Chief of the Railway Hospital) reports that for the last four years, he has noticed deaths from some infectious disease in the region of Tungliao. On the 30th August, he received news from the station master that for the previous two weeks 2-3 deaths have occurred daily in the eastern section of the village of Chien-Chia-Tien. Altogether there might have been some 20-50 deaths from some acute illness lasting only a few days. They seemed to be scattered over that part of the village, mostly isolated ones in a house, but there were sometimes 2-3 in the same household. He went down to investigate forthwith, but just missed a corpse with cervical bubo, because it had been nailed up in a coffin. The *symptoms* were said to be fever, red eyes, unconsciousness (? delirium), tightness in the chest; some cases had buboes, rashes, and diarrhoea near death. The disease seemed to last usually 3 days. No cough or spitting of blood has been noticed.

Dr. Wang's report. For the last week Dr. Wang has been going to the village from Tungliao (15 miles) daily and inspecting the neighboring region with two policemen. He said he saw no buboes (?). The patients had fever. From two patients he took blood from the basilic veins and made smears, but could see no bacteria (the microscope was not powerful enough), but there seemed to be leucocytosis. None had lung symptoms.

Two Japanese S.M.R. doctors went down on the 2nd. September and saw a young male cake-seller. He had fever, and right femoral bubo from which blood was withdrawn and proved by Dr. Kanai in Dairen to be full of *B. pestis*. Later on, all tests including animal and agglutination tests confirmed Bubonic Plague. The patient in question was seen on the second day of illness and died on the third day. He also showed no lung symptoms.

Description of the village. The surrounding country is sandy and sparsely cultivated. Kaoliang is the principal crop. No tarabagans abound. The villagers are mostly farmers. There are 100-200 mud houses with flat thatched roofs, and mud floors. The village is situated about $\frac{1}{2}$ mile from the station on north side.

The police are very apathetic. The infected east-side was supposed to be isolated from the west by stretching 3 ropes across the main street. The whole village was quarantined by the cancelling of passenger traffic, and by the stopping of foot passengers by police (this was not enforced strictly owing to the open country). On arrival, we were told by one of the station staff that a Mahomedan native doctor (Li) had died that morning. We hurried to the police station, and obtained two men to go with us to visit the house. On going along the main street, we saw a sick young man in a barber shop. He was said to have been ill for some 14 days. He had fever and furred tongue. No diarrhoea. No buboes. No enlarged spleen. No physical signs anywhere. Fever was about 101°F. The mother of the patient was reduced to hysterics by our presence, and "make-up" (white apron, mask, hood and gloves). The second case was a man of about 40,

living in a small isolated hut with his wife and child. He was seen by Dr. Wang the day before and some blood was taken for examination. At that time the result was negative. He also had fever. No buboes. No lung signs. No enlarged spleen. He was in his third day of illness.

We then directed our attention to the Mohamedan's house. There were four members of the family left. Wife, sons and brother were all well. No history of death among rats about the premises. The corpse was laid out in the inner room, covered with a blue cloth. The wife (an old lady) refused to allow us to see it until we threatened her with eviction. On removing the cloth, the body was that of a strong man of about 50 years of age. Bluish in color. *Rigor mortis*. A patch of subcutaneous haemorrhage on the left hip. No cervical or axillary buboes. But there was a large left femoral bubo. On incision, blood was withdrawn on knife and smears and cultures were made. Dr. Li withdrew some blood with a syringe, made smears for himself and injected two white mice which died 15 hours afterwards. The smears were examined afterwards and found to be full of typical *B. pestis*.

The deceased had died on the morning of third day of illness. The appearance of the corpse gave an impression of severe septicemia. Owing to loud protests from the wife, nothing further could be done in the way of investigation.

Measures already taken. Beyond stopping the sale of tickets to and from Chien-Chia-Tien, and asking the police to keep the affected village isolated, the railway had done nothing more than keeping a sharp look-out on the number of deaths reported daily both in the village and Tungliao (reports from this place seemed to indicate the presence of two suspicious deaths on the 7th.).

Measures recommended.

1. The stoppage of all passenger traffic from the junction Chengchia-tun to Tungliao, and from Tungliao to Tahushan connecting with the P.M.R. and thus Fengtien and Peking.
- Alternately 2. The stoppage of tickets at Chien-Chia-Tien, Talin, Tahan, and enforcement of quarantine measures at Tungliao or medical inspection. The same for Chengchiatun and Ssuping kai.
3. In connection with one or two, the local authorities must be pressed to keep a sharper look-out on the isolation work by strictly surrounding the village, and stopping all foot passengers.
4. The establishment of an anti-plague bureau which will have to carry out the work of hospitalising the sick, quarantining of the contacts, disinfection of the houses, disposal of corpses, etc.

REMARKS

1. Dr. Li thinks the infection must have been smouldering at a little distance from the village, and that it has now finally infected it.
2. The patients are among family people, not travellers or inndwellers. It was very difficult to get hold of any material for examination, from

patients or corpses because of objections raised by relatives. It was lucky that we came across a Mahomedan, because of the custom of not having any clothes on the corpses, so that no undressing need be done. The people tried to bury the dead as soon as possible. They offered much passive resistance, and no doubt tried to hide their dead. Some are said to have run away to Tungliao after deaths have occurred in the family.

3. The Magistrate in Tungliao does not seem to take any notice and the police are apathetic. They need to be stirred by pressure from Fengtien authorities.
4. The Ssupingkai-Taonan Railway chiefs are afraid to acknowledge the presence of plague officially, owing to the attitude of the Fengtien authorities last year, and also the lack of funds for anti-plague measures. The railway chiefs did not wish to hold a meeting to discuss the plague situation.
5. They look to our Plague Prevention Service to furnish everything, including funds. The most urgent seems to be vaccine and serum.
6. The Railway doctors are keen men, willing to work, but with little knowledge or experience.

APPENDIX 5.

Plague Mortality at Chien-Chia-Tien 1928, according to Railway Statistics

	Date	Village	Vicinity	Total
September	1-8	37		37
	9	9		9
	10	8		8
	11	4		4
	12	5		5
	13	7		7
	14	5		5
	15	20		20
	16	11		11
	17	15	4	19
	18	10	4	14
	19	6		6
	20	8		8
	21	13		13
	22	7		7
	23	7		7
	24	8		8
	25	4		4
	26	8		8
	27	3		3
	28	4		4
	29	6		6
	30	10	7	17
October	1	4		4
	2	2		2
	3	3		3
	4	2		2
	5	2		2
	6	1		1
	8	3		3
	9	1		1
	10	2		2
	11	2		2
	13	2	25	27
	14	1		1
	17	1		1
	22	1		1
November	24	0	2	2
	26	1		1
	27	1		1
	3	0	6	6
	7	0	1	1
	9	0	2	2
		244	51	295

APPENDIX 6.

TENTATIVE PLAGUE AGREEMENT BETWEEN CHINESE
GOVERNMENT AND SOUTH MANCHURIA RAILWAY

1. On Chinese side the highest medical authority is Dr. Wu Lien-Teh, while on S.M.R. side Dr. S. Kanai is the highest authority. Dr. Wu has received full authority from the Fengtien Governor to take charge of all anti-plague measures in Chinese territory. In Dr. Wu's absence, Dr. Li Te-Chuan or some other assistant appointed by Dr. Wu will act for him. In the case of Dr. Kanai either Dr. Nakadate or Dr. Horui will act.
2. Each side is to be responsible for the management of its own affairs.
3. Mutual exchange of information every day. Such information to be regarded as official for publicity or other purposes.
4. Both sides to have temporary anti-plague headquarters at Ssupingkai, where offices and laboratories have been established.
5. On the Chinese side the following principal arrangements have been made:
 - a. Every station has a doctor or assistant; senior medical officers are stationed at Tungliao, Chien-Chia-Tien, Talin, Chengchiatun, Pamien-cheng, Sanlin and Ssupingkai.
 - b. Spacious quarantine camps at Chien-Chia-Cien and Chengchiatun. In case of necessity, also at Ssupingkai.
 - c. Every passenger train to be accompanied by medical officer on Chengchiatun-Tungliao, Taonan-Ssupingkai and Tahushan-Tungliao Lines.
 - d. Quarantine arrangements to be:
 - i. period of 5 days.
 - ii. disinfestation of clothes and personal effects.
 - iii. rat destruction by appropriate methods.
 - iv. examination twice a day for fever, bubo, etc.
 - v. immediate isolation of sick when found.
 - vi. anti-plague vaccination of contacts and others.
 - vii. serum treatment and other medical measures for sick.
 - e. If necessary open medical stations at Changwu, Tahushan and Mukden on Tatung Line. Yinkow has already instituted medical examination and quarantine station.
 - f. *Cargo.* Prohibit skins, furs, bones and similar dangerous goods for conveyance. Grain and cereals are free.

6. On the Japanese side the following arrangements are made:
- Quarantine station established at Ssupingkai for 1,000.
 - Disinfection and laboratory already established at above.
 - Passengers after detention at Chengchiatun can pass freely to South Manchuria Railway trains.
 - Quarantine doctors and officers stationed at Ssupingkai, Mukden and Yinkow.
 - All stations between Changchun and Mukden have Quarantine Office.
 - Doctor on every train between Mukden and Changchun.
 - Strict control of passengers travelling by road to South Manchuria Railway.

Ssupingkai, September 19, 1928.

APPENDIX 7.

PLAGUE INVESTIGATION REPORT OF CHAN-YU

R. POLLITZER

Leaving Ssupingkai on the 22nd of October at 7 o'clock a.m. we arrived at Tai Ping Chuan station of the Chengchiatun-Taonan line at 12.25 p.m. Here we were hospitably received by the Railway doctor Yang Fu-Chang (楊福昌).

Soon after our arrival we boarded the motor-bus to Chan-Yu. This was a rather dilapidated-looking Ford, which, however, ran with commendable efficiency. The bus being overcrowded, it took about 3 hours to cover the 25 miles between the station and the city. The country is slightly hilly. Soil and vegetation are evidently poorer than in the Tungliao District. Settlements are also both sparser and smaller. Yet agricultural patches (mainly kaoliang fields) are to be seen everywhere, the rest of the country being covered with short grass and thorny brushes. Much cattle and horse breeding is done. The traffic on the road is not dense though we met some carts bringing produce to the station and passed others which were loaded with goods for the shops of the city. It takes a cart 10-12 hours to cover the distance.

Chan-Yu is an important city, having about 8,000 inhabitants, half of whom are Mongols. It is surrounded by a high mud-wall, kept in good repair, with four gates which are closed at night. There are, however, quite a number of houses and compounds outside the wall. Here also the house set aside for accommodation of patients is situated. The streets of the city, especially the more important ones, are wide and kept clean. The houses are mainly made of mud, the brick ones being rather in a minority. As everywhere in these parts the number of shops would seem surprising until it is considered that the few settlements form the

commercial center for a large district around them. Though the place seemed thriving it was poorer in every respect than Tungliao City, for instance.

After our arrival we went to the Yamen (where the anti-plague bureau is established). Here we were hospitably received by the Chief of the Prefecture, Mr. Chang Chi-Chun (張其軍) a scholarly man who had studied in Peking and Japan and had formerly lived for some time in Harbin where he held a position in the Special Area Police. In addition to a little Russian he spoke good English. Besides the above mentioned information about the population, etc., of the city I am indebted to him for the following :

Population of his district is about 50,000, among them many Mongols living in settlements of their own. They live in Chinese-style houses and are, in the Magistrate's opinion, of very dirty habits.

Asked about the plague he estimates the number of cases in the district at 38. He adds that owing to the sparsity of the population the disease has little chance to spread. Like our Medical Officer Mr. Chang considered it quite likely that infection had been originally imported from Chien-Chia-Tien, saying that a coolie running away with things stolen from the dead reached the south-west corner of his district where he died. Then the disease spread. He thought that polluted water is the most dangerous vehicle of infection but - having heard of the rôle of the mosquito in malaria transmission he lent a willing ear to the flea theory expounded by me.

The Magistrate confirmed my observation that there are many rats in the city. Sisels are present in the district but not very numerous; the same holds true in regard to jumping rodents. Mr. Chang did not at first like the idea of my making a trip into the district; he said that it is badly infested with robbers and complained bitterly of their activity. Finally he agreed to go out with me the next day.

The temperature went below zero during the night but I slept comfortably in Mr. Chang's private office kindly put at my disposal.

On the 23rd, about 11 o'clock in the morning we left Chan-Yu for a trip on horseback. Our Medical Officer and I were kindly accompanied by Mr. Chang and the Chief of Police (潘兆早) and quite a *posse* of body guards and police soldiers. We first visited the Chinese village Katawantung (疫瘧王屯) ca. $\frac{3}{4}$ of an hour ride from Chan-Yu, where according to our Medical Officer 14 plague deaths had occurred among a population of 47. I saw one house of very poor mud-construction where all inhabitants had died and another where but a few cases had occurred; this was similar to the poorer houses of Chien-Chia-Tien village. In the former especially were numerous ratholes. The inhabitants as well as the local police testified to the presence of many rats but claimed to have seen no dead ones. They stated that jerboas are to be found only far away from the village and promised to go out and get some for us after we had left. The Magistrate told me that they had found some rodents when excavating earth to repair the wall around the settlement. I saw the hole but the story seemed very circumstantial.

Then we left for the Mongol settlement Talapayintze (塔拉巴營子) situated farther north. This place, also surrounded by a wall, was small, comprising only a few houses. I visited one of them which, like the others, was in outer appearance and general arrangement quite similar to poor Chinese houses. The only important differences are:

1. One corner of the houses is set aside as a shrine for the gods.
2. The *k'angs* are not heatable, consisting simply of mud benches on which lie blankets, partly made of felt (woollen material) and similar to the *kochma* so largely used by the Kirghese in South-East Russia.
3. The rooms are heated by open fires, large iron pans being placed on mud supports for this purpose. As firing material they use the dried bramble-bushes abounding in the fields, not cow-dung.

A rough plan of the house is herewith given:

- a. Kitchen.
- b. Sleeping room.
- c. " "
- d. Single-paned paper windows.
- e. Entrance door.
- i. K'angs.
- ii. Fireplaces.
- iii. Kitchen stove.
- iv. Shrine.
- v. Cupboard.
- vi. Large earthenware vessels, containing fermenting cabbage.

Outside the house there were 3-4 small out-houses to accommodate cattle and horses, stores, a hand-mill, etc.

I did not find the place any more dirty than those of Chinese peasants in similar circumstances. The inhabitants looked quite healthy. I could not detect any visible signs of luetic infection; there were 3-4 healthy-looking children in the family.

Rat holes were seen in the outbuildings especially, and the inmates admitted the presence of rats. They also promised to obtain jumping rodents for us but it could be seen at once that they were not keen about this.

Having to return with the whole cavalcade I had no opportunity to look around for wild rodents myself. All I could do was to note the presence of suspicious holes. Especially near the town these looked like siseh-holes; here they were not very numerous and seemed in part deserted.

The Magistrate invited me to stay in Chan-Yu until the promised rodents arrived from the villages but I left with many thanks for his hospitable reception as well as that of the Chief of Police and Dr. Chang on the morning of the 24th at 7.20, reaching the station at 9.30. The bus not being so full, travelling was much quicker.

Appendix:

The Magistrate thus described the plague organisation in his district:

There are five isolation rooms in the following localities:

1. Chan-Yu (瞻榆);
2. Katawantung (疙疸王屯);
3. W. Chakanalapuko (西干撓拉不克);
4. E. Chakanalapuko (東干撓拉不克);
5. Tunghua On Ton (東華歐豆).

The police of the infected villages (4 in number) get increased pay (\$20 instead of \$15). Altogether there are 12 such police. The members of the local plague committees get 200 small dollars and expenses each. The Magistrate was very pleased with our Medical Officer Chang and seemed anxious that measures should not be stopped too soon.

October 24, 1928.

APPENDIX 8.

A BRIEF REPORT OF PLAGUE AT NUNGAN DISTRICT

CHANG CH'1-CHUN, MAGISTRATE

1. The present plague at Chichin or Manchu area (not under the Nungan magistrate's control) may be traced back to the first victim, a Buddhist monk (name?) who with his two pupils visited the place and stayed at an inn for the night. Next morning the monk with one of his pupils and the owner of the inn were found suddenly dead. The remaining pupil escaped with his luggage to the south (10 li away) but died on the way. Owing to the fact that all the inmates of the inn had died, nobody knows where the monk came from.

2. The symptoms of the deceased were fever, dizziness, tiredness, and cough. The duration ranged from 6-9 hours to 1-2 days; there was blood spitting, but no buboes when dying.

3. The place Chienchi is 80-90 li away from 4th and 5th areas of Nungan; there Chinese and Mongols live together.

4. The prince called Kuo-erh-losu resides at Chienchi; no other authorities are stationed there. The places Nungan, Fuyü, Changling, and Chienan cover a wide area with one or two scattered abodes separated from each other; the people are quite ignorant. Though the Magistrate found that an epidemic was prevalent, the people were against any steps taken by him. Luckily the situation of the scattered abodes formed a natural quarantine for them and therefore the epidemic was not difficult to stamp out.

5. The present epidemic at Chienchi is now over, no more fresh case having developed. The city had some years ago suffered from a like epidemic, and had been free ever since.

6. On December 3, in the 5th area of this district the son of Tsao Hung-Hsi living in Kaochiatien returned home from Chienan district. During the night he is said to have suffered from headache and blood spitting. He died next morning after two days' illness.

The second case occurred in the 4th area of this district. A youth named Yang Chen-Hai, who lived in a hat shop (Tien Cheng Tien of Halahaichengtze) came from Chienchi and suddenly died with symptoms of blood spitting after drinking water. After the death of these two persons, disinfection was at once started, all things connected with the patients were burnt, contacts were isolated, the corpses were buried with lime in coffins. The area has been free from infection ever since.

7. The provisional plague bureau is established within the city hospital, quarantine stations are established in the neighboring Mongolian territory near the 4th and 5th areas of the district. Communication is interrupted, Medical Officers with medicine and sanitary coolies are dispatched to the Mongolian frontier for performing plague prevention work, such as burning corpses, disinfecting houses, etc.

8. All cases mentioned above are not yet confirmed by any modern physician; the symptoms are reported by the families whose relations have succumbed to the disease.

APPENDIX 9.

TUNGLIAO PLAGUE BUDGET (SEPT. 20-NOV. 20, 1928)

1. Salaries Director and 3 Chief Medical Officers	2,000.00
Senior Medical Officer (15)	4,000.00
Asst. Medical Officer (8)	950.00
Male Nurses (11)	1,635.00
Lay Staff Head Office (13)	899.00
Attendants	641.00
2. Compensation to family of Lab. Att. Huang	302.00
3. Vaccines, Serums, Disinfectants and Medicines	5,598.00
4. Apparatus	1,611.00
5. Travelling expenses	902.00
6. Printing and pamphlets	205.00
7. Postage	62.00
8. Telegrams (after Oct. 1 free)	137.00
9. Misc. purchases	520.00
10. Petty expenses	218.00
11. Tungliao special expenses	2,160.00
12. Chengchiatun Quarantine Camp	1,674.00
13. Chien-Chia-Tien (Plague Hospital and Laboratory)	646.00
14. Tai Ping Chuan	60.00
15. Talin	20.00
16. Pamiencheng	13.00
17. Chan-Yu (Magistrate)	450.00
18. Li Shih (Ssupingkai City)	140.00
19. Coal and electricity	309.00
20. Miscellaneous	497.00
	<hr/>
Silver dollars	25,550.00

APPENDIX 9.

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Types of Bubonic Plague — A

各種腺型 (一)



17. Double Cervical, 雙頸 18. Left axillary, 左腋腺
 19. Right femoral (cured), 右腿腺 20. Double inguinal, 雙鼠蹊腺

Types of Bubonic Plague — B

各種腺型 (二)



21. Left axillary (cured), 左腋窩 22. Left ing-femoral, 左腿鼠蹊
 23. Septicemic (Mongolian), 敗血症(蒙人) 24. Ulcer in abdomen and scratches all over but not plague. 腹部潰瘍及各部傷痕但非疫屬

Types of Bubonic Plague — C
Recoveries

各種腺型治愈者 (三)



- 25-26. Girl of 12 during sickness and after recovery. 十二歲女孩霍疫與愈後
27-28. Woman with left submaxillary bubo during sickness and a week after, recovered. 左顎下腺腫之婦霍疫與愈後一星期
29. Right popliteal bubo in boy, recovered. 右膝節下胎腫已愈

Worst infected locality of Chen-Chia-Tien

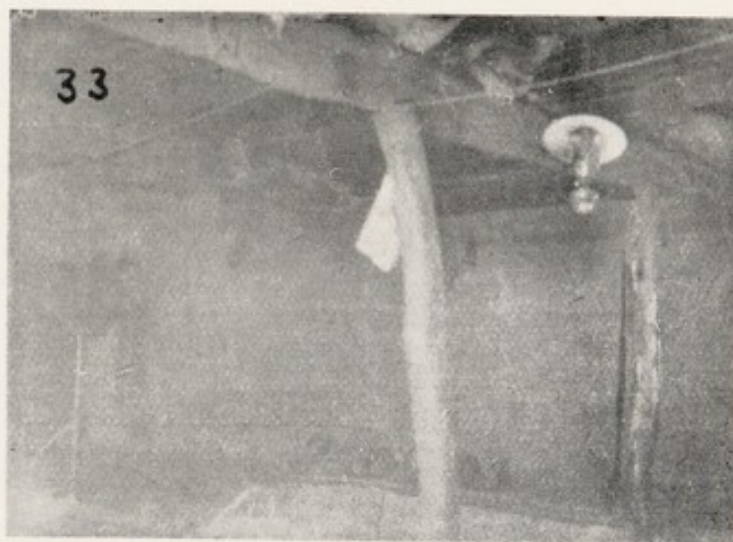
錢家店發生鼠疫最多地點



14. Main street, Chien-Chia-Tien, Sept. 1928. 錢家店大道 (民國十七年九月)
 15. Searching plague patients in a poor quarter. 在窮家搜查疫者
 16. Finding a dying plague patient; blinds and window frames opened for photographing. 由病將臨危之窮家搜查疫屍
 30. Dog watching empty hut after all inmates had died. 全家疫亡狗猶在門前守戶

House to House Inspection

挨戶檢查



33. Inside the inn at Chien-Chia-Tien where over 40 persons died of plague. 錢家店疫戶內容此處已疫死四十名
34. Anti-plague staff outside the above inn. 防疫員在戶外
35. Anti-plague workers at Chien-Chia-Tien with Dr. Liu in charge of work on right. 在錢家店防疫員右邊為劉醫官

Quarantine Methods

隔離辦法



39. Carting contacts to quarantine camp. 車送接觸者至隔離所

40. Military barracks used for quarantining plague contacts. Chien-Chia-Tien. 錢家店借兵營為隔離所



41. Some contacts in quarantine. Mostly women and children, Dr. Wu on left. 在隔離所接觸者多屬婦孺左方為伍博士

31. Examining passengers, Chengchiatun Junction 在鄭家屯車站檢驗旅客



Field Investigations

野外視察



36. Searching for fleas and lice on clothes of dead. Assistant on left had glass tube for holding parasites. 由屍體衣服搜捉虱蚤立左之助手持試驗管載虱蚤

37. Performing post-mortem in open air next to burning pit. 在焚屍坑行露天解剖術



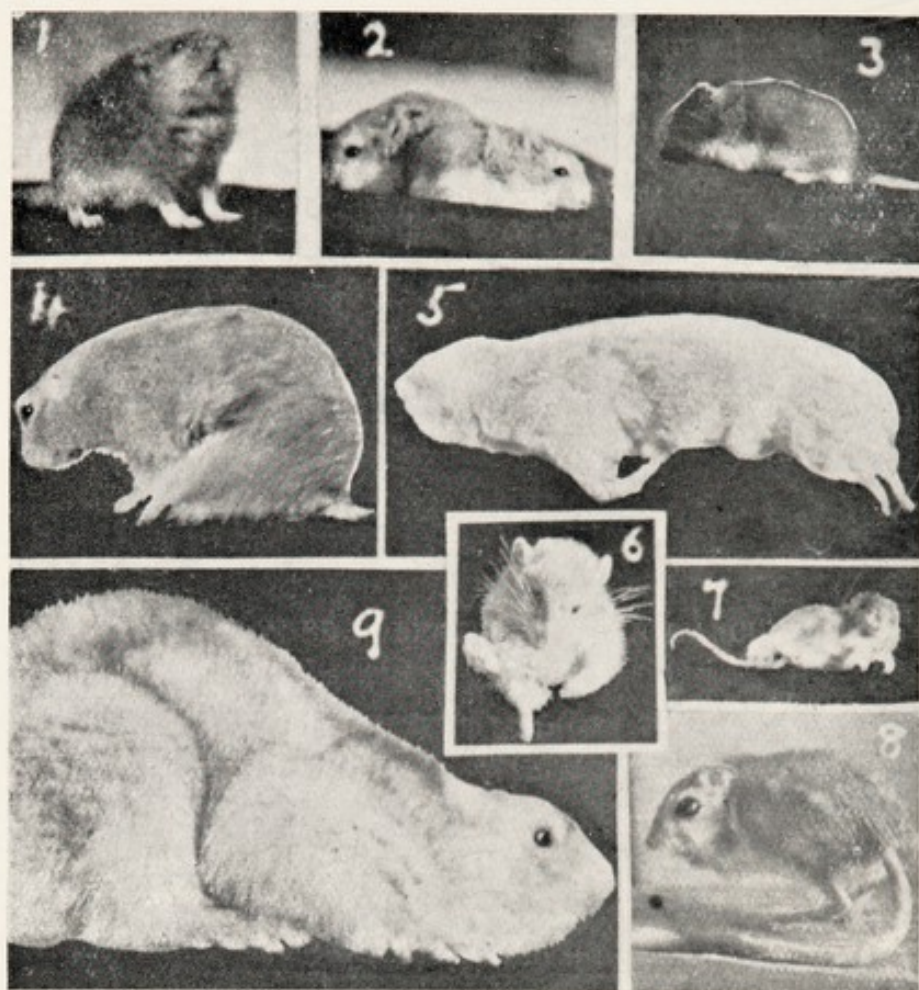
42. Sand-dunes in Tungliao district inhabited by small hamsters. 通遼縣小砂漠爲小咸士特鼠居住

43. Digging out burrow of hamster, Tungliao, 1928. 掘出咸士特鼠穴 (通遼縣)



TYPES OF WILD RODENTS FOUND IN MANCHURIA

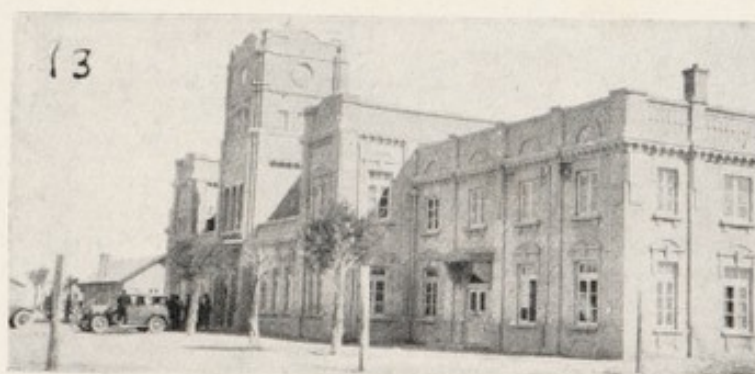
東省產野齧齒動物類



1. Small hamster (*Cricetulus X*) near Mongolia 蒙古附近產小咸士特鼠
2. Sand hamster (*Cricetulus Y*) Tungliao 通遼產砂咸士特鼠
3. Small hamster (*Cricetulus furunculus Pall*) Sansing 三姓產小咸士特鼠
4. Small marmot (*Spermophilus manchuricus*) Tungliao 通遼產小豆鼠
5. Gray mole rat (*Siphneus aspalax Pall*) Sansing 三姓產灰鼠
6. Small hamster (*Cricetulus arenarius*) Sansing 三姓產小咸士特鼠
7. Wild mouse (*Mus spec*) near Harbin 哈爾濱產野鼠
8. Jerboa (*Lipodipus sp.*) 錢家店產跳兔子
9. Tarabagan (*Arctomys bobac*) Manchouli 滿洲里產旱獭

Railway Stations in Plague Area

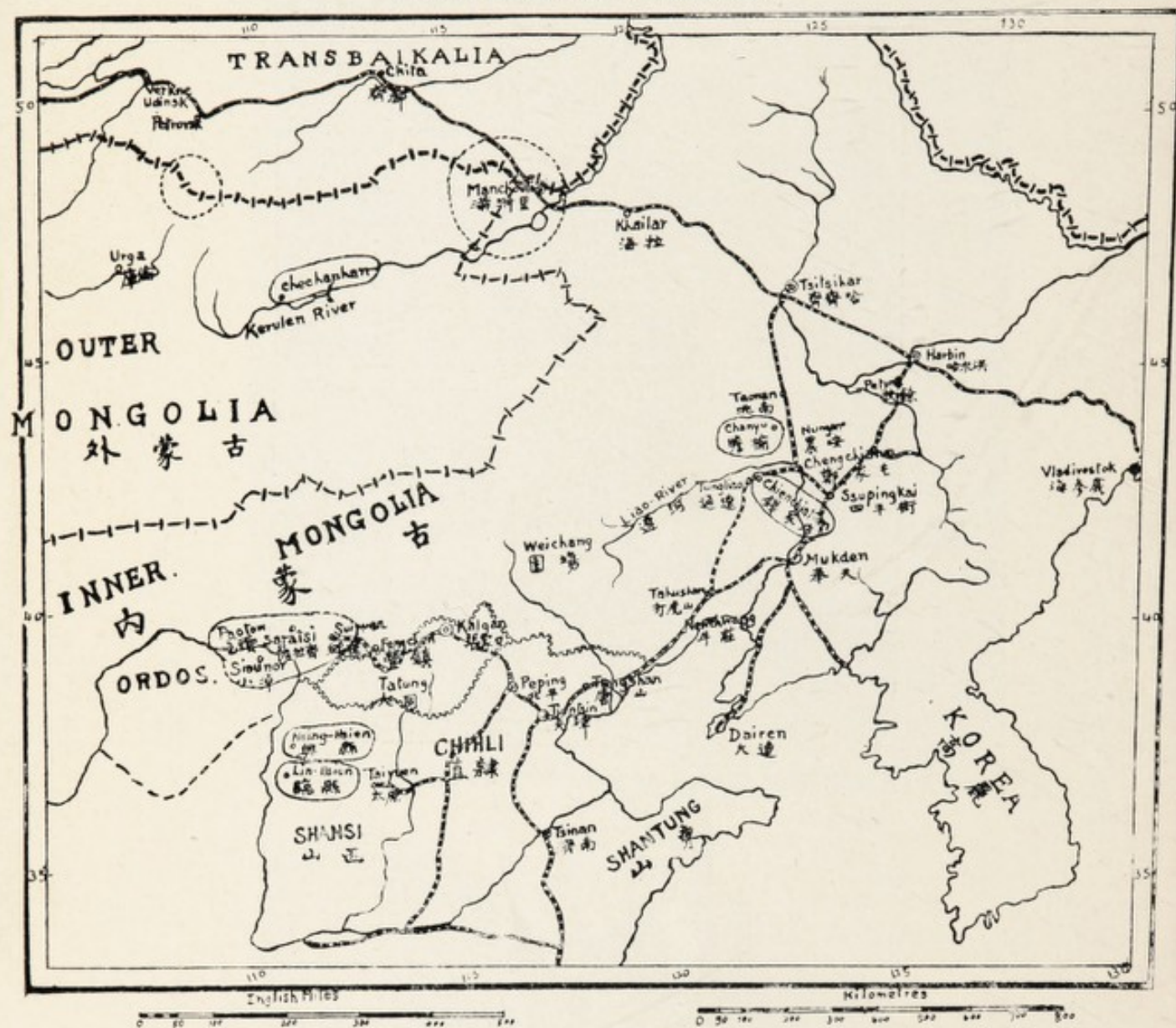
四洮路車站



10. Ssupingkai Station, S. M. R. 南滿路四平街車站

11. Chien-Chia-Tien Station with medical staff. 醫官在錢家店站

13. Taonan Station (Ssu-Tao Rly.) 洮南車站 (四洮鐵路.)



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