The Sylvatic Plague Committee*

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A. ADMINISTRATIVE ACTIVITIES

THE executive committee in consultation with Dr. Ira N. Gabrielson, Chief of the U. S. Biological Survey, Washington, C. Gill of the Federal Works Progress Administration, and Assistant Surgeon General C. E. Waller of the U. S. Public Health Service, has aided the members of the committee in the preparation of state projects for rodent control. The California project was submitted on March 1 by the Department of Agriculture (total estimated cost $84,490). The committee members have been informed relative to newer developments by 6 confidential circular letters and copies of the minutes covering the meetings of the executive committee. Antiplague serum in small amounts will be kept available at the George Williams Hooper Foundation, Medical Center, San Francisco, Calif.

B. SCIENTIFIC ACTIVITIES

The Sylvatic Plague Committee has continued to collect information concerning the extent of human and rodent plague on the American Continent. The observations on sylvatic plague in 1936 and the interpretations of the scientific facts may be summarized as follows:

A. HUMAN PLAGUE

Four non-fatal human cases of plague have been bacteriologically proven. There is strong indirect evidence that a 5th case was infected with the plague bacillus. Three, most likely 4, cases occurred in California and 1 in Utah. The histories of these cases are very interesting and deserve detailed comment.

California Case 1—Veterinarian, age 37, Santa Rosa, Sonoma County, noticed on April 3, 1936, malaise, fever 102° F. and pain in the left axilla. In the left axilla one firm node, 3 to 5 cm., was felt; the skin over the node was erythematous and of brawny induration; no lymphangitis. On April 9 the patient was hospitalized in San Francisco. He appeared extremely ill and prostrated. The node was punctured and a few drops of fluid were cultured. On April 12 the broth enrichment culture yielded typical *P. pestis* which were readily agglutinated by a specific antiplague serum. The blood culture taken on April 9 was positive for the same organism on the 4th day of incubation. On April 15 his temperature reached a normal level but a sharp rise due to an old arthritis occurred on April 19; within 5 days it subsided and the patient was discharged on the 27th day; recovery has been uneventful.

Since this case of *pestis minor* originated in a county in which neither murine nor sylvatic plague had been recognized, a searching investigation was instituted. It was learned that the veterinarian had on March 31, 2 days before the onset of his illness, treated an 8 months old cat with an

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abscessed jaw, brought to the hospital from a cabin in a forest region in which rodents are rarely observed. The cat died before a diagnosis could be made. Inquiries revealed that the cat had some contact with a skunk a few days before the swelling developed on the jaw about March 15. In the course of the survey, 476 rodents—rats, mice, and squirrels—*Citellus douglasii* (286 specimens) were examined but no gross plague infections were established. Suspicion was therefore centered on the cat and the knowledge concerning plague infection in this carnivore has been collected and is summarized.

The susceptibility of cats to plague was first established by the Austrian Plague Commission by feeding them with the bodies of animals dead with *P. pestis*. McCoy and Chapin, Toyama, and others have also reported the susceptibility of cats. Spontaneous infections (12 cases) have been observed and bacteriologically proven by Robertson at Cape Town (1901); the type was bubonic affecting the glands of the neck and submaxillary lymph-nodes. Similarly, Hunter in Hong-Kong saw cats, which were used in the hunting of infected rats, suffer from acute or chronic plague. However, important is the recent report by Pirie in South Africa (personal communication) who found among 11 cats 2 with plague bacilli in the spleen. Neither animal had obvious lesions of plague and it seems probable that cats may often die from a surfeit of plague-infected rodents (? from a toxemia) without becoming definitely infected. Other carnivores, such as the suricate and the yellow mongoose, are frequently found dead in the wake of a plague epizoötic but without actual infection.

Although the rôle of the cat as a possible link in the transmission chain of the *P. pestis* from rodents to man should always be kept in mind, it must be emphasized that the owner of the cat involved in the Sonoma case had very intimate contact with the pus removed from the abscess 2 days before he brought the animal to the veterinarian. He has remained well. The veterinarian remembers that he used his right hand in lancing and swabbing the abscess, while his bubo developed on the left side. The history of the only dog brought to the hospital and professional visits of the veterinarian were carefully investigated but the source of the plague infection in Sonoma County remains unexplained.

California Case 2—An 11 year old boy living in an isolated section of Monterey County, Calif., while cleaning a brush rabbit on June 13, cut his right thumb on a bone. No infection developed locally, but June 16 he complained of pain in the right axilla and was not feeling well. June 17 he had headache and considerable pain in the axilla and was taken to the hospital—temperature 104° F., pulse 96, respiration 22—prostrated and toxic, swelling in right axilla. On June 18 the temperature was 105.6°. Smear from bubo apparently showed bipolar organisms. Blood was inoculated into guinea pigs. June 19 the patient was much improved, temperature 103.8°. June 20 the maximum temperature was 103°; bubo was definitely palpable and tender. From this time on the patient showed gradual improvement, and June 23 the temperature was normal. June 25, guinea pig inoculated with blood taken June 18 died, and smears from organs showed many typical bipolar organisms.

Ground squirrels and brush rabbits are plentiful in the locality, but the patient denied shooting any ground squirrels recently, although his dog frequently brought them in. Ticks are plentiful, and he had been bitten by one 4 days before illness.

The examination of 1,378 rodents (*C. beecheyi* and rats) failed to reveal plague infected animals. In September *a pool of 259 fleas from 58 Citellus beecheyi* collected in an area north of the place in which the human infection occurred was *proved to be infected with P. pestis.*

California Case 3—A woman, age 50, living

in her summer cottage at Tahoe Vista, Lake Tahoe, Placer County, became ill July 23 with chills, high fever, nausea and vomiting, headache, and prostration. July 25 relapsing fever was suspected and 0.4 gm. neoarsphenamin administered. The blood smear proved negative and the patient was transferred to Reno July 27. A blood culture July 29 yielded a Gram-negative bacillus. August 1 small pustular lesions became evident on the outer surfaces of both lower extremities near the knee and hip joints. A few days later several large indurated areas were apparent on the left hip and the outer surface of the right leg just below the knee. On incision, several drams of thick purulent material was obtained. An organism indistinguishable from that isolated from the blood was cultivated. The patient was very ill and ran a fairly constant temperature around 103° F. for 1 week. With gradually subsiding temperature, normal was reached at the end of the second week and remained so until discharge on the 25th day after entrance. The 5 large abscesses drained for several weeks and healed uneventfully. The treatment was symptomatic; blood transfusions and intravenous sodium salicylate were given. The etiologic diagnosis was made by an identification of the two cultures —blood and abscess material—as *P. pestis* by the Hooper Foundation. Blood collected September 5, the 44th day of illness, agglutinated the plague bacillus in a dilution of 1:80.

As an isolated observation, this case offered diagnostic difficulties and without the cultures would doubtless have escaped etiologic identification. The absence of local or general lymphadenopathy failed to suggest bubonic plague. However, septicemic plague associated by petechiae and pustules with cellulo-cutaneous necroses in the gluteal region have been seen by many observers even in ancient times. This so-called carbuncular variety, as a rule, appears only at the middle and decline of an epidemic when the type of the disease is less fatal. It is generally believed that the mortality of this type is less than the bubonic form.

Inquiries disclosed the important fact that the woman buried a dead chipmunk about a week before the onset of her illness. She did not notice any type of insect bites and did not see any ticks. Although 999 rodents (*C. beecheyi, Sciurus, Callospermophilus, Eutamias, Glaucomys,* etc.) were examined, no plague infections were demonstrated. *Three batches of fleas collected from these rodents and tested on guinea pigs proved to contain P. pestis.* In October, Dr. C. R. Eskey proved the plague in a Tahoe chipmunk (*Eutamias quadrivittatus Frate*) trapped about 30 miles from the region in which the human case had occurred.

California Case 4—A 10 year old boy with a history of a squirrel bite without penetration became suddenly ill at a camp in the San Bernardino Mountains June 26, 1933; vomiting and high fever were recorded until he was hospitalized July 1. Chief symptoms—highest temperature 104.4°, remittent type, enlarged tender inguinal, axillary and cervical lymph-nodes; a punched out ulcer ½ cm. in diameter on the back in the region of the twelfth dorsal vertebra; pin-point papule on the abdomen left upper quadrant; July 22 normal temperature; uneventful recovery. Laboratory examination of cultures from the ulcer revealed Gram-negative bipolar bacilli; since the cultures were lost, no definite identifications have been made. The blood serum repeatedly tested by several laboratories failed to agglutinate *Bact. tularense,* but on the 39th day after the onset specifically clumped *P. pestis* in a dilution of 1:80 (4+) and 1:160 (3+).

In retrospect, the illness of this boy is correctly diagnosed as *Pestis minor* with a cellulo-cutaneous necrosis. Survey activities and post-mortems conducted in the Big Bear region during September and October on 1,302 rodents (406 Fisheri squirrels, 128 Golden-mantled chipmunks) failed to reveal one single plague infection. However, *2 pools of fleas, 1 of 104 insects collected in August from 38 Citellus beecheyi fisheri and another of 31 fleas from 24 squirrels shot in October in the Holcomb Valley infected guinea pigs with P. pestis.* The demonstration of infected fleas in the San Bernardino area not only supports

the anamnestic diagnosis made on the above case but also establishes the source of infection of a fatal case of human plague seen in a 67 year old male in 1933. Epidemiologically the evidence favored exposure to plague in the Big Bear region where the man owned a cabin; but since no infected squirrels had been found during the extensive surveys made from 1933 to 1936, the correctness of the epidemiologic reasoning was questioned. The examination of fleas solved one of those irksome riddles continuously encountered in the elucidation of sylvatic plague.

Utah—Early in July Dr. M. J. Macfarlane from Cedar City, Utah, submitted to the Hooper Foundation a specimen of pus removed from the axillary bubo of a 7 year old boy. The examination yielded an abundance of plague bacilli. From the history the following data are of general interest. June 24, 1936, the boy had been bitten on the left thumb by a squirrel. He was hospitalized June 29 with a high temperature and a provisional diagnosis of tularemia. Symptoms of meningismus, meningitis, and diphtheria dominated the early clinical picture. Subsequently, extensive maculopapular eruptions over the trunk and limbs with necrosis and suppuration accompanied by 5 buboes—1 in the left axilla, 2 in the cervical and 2 in inguinal regions—made their appearance. A typical bronchopneumonia accompanied these septicemic manifestations. The boy eventually recovered and was discharged from the hospital after 54 days. A critical analysis of this case leaves no doubt that similar observations may be made any time and anywhere and that the nature of the successive clinical diagnoses of meningitis, diphtheria, streptococcic sepsis, and tularemia may be clarified only by proper laboratory examinations.

Through the subsequent survey activities of the U. S. Public Health Service, the existence of sylvatic plague among the squirrels (*Citellus grammurus*), marmots (*Marmota flaviventris englehardti*) and prairie dogs (*Cynomys parvidens*) was fully proved.

The observations on 5 human plague cases in 1936 may be summarized as follows:

1. Despite the serious septicemic nature of the infections, the patients made uneventful recoveries. The plague strains involved possess the same infectiousness for guinea pigs as established for other cultures isolated from man and rodents during 1933 to 1935.

2. In 4 of the 5 cases direct contact with squirrels and other rodents was established. It is significant and noteworthy that the histories fail to report flea bites.

3. The importance of early laboratory examinations of the blood, aspirated lymph-node juice and pus, by experienced bacteriologists and serologists is again emphasized. The value of the diagnostic serologic examination of the blood serum of patients suspected of plague deserves recognition.

4. From a preventive point of view, it is imperative that the public, particularly youths, be warned not to handle sick or dead rodents in the regions in which sylvatic plague has been recognized. The character of these warnings should be judiciously worded in order to prevent harm to the summer resorts and to avoid criticism by the uninformed.

B. RODENT PLAGUE

1. *California*—Accidentally a squirrel (*C. beecheyi*) with sub-acute plague was found by the Agricultural Commissioner in an area adjacent to an old sylvatic plague focus in Ventura County. The examination of 104 squirrels and 2 rats (*R. alexandrinus*) were negative for plague but *a pool*

of 317 fleas collected from 25 rodents was proved to carry P. pestis by animal inoculations.

The plague area discovered in 1934 in Northern and Eastern Modoc County is slowly extending south, and on the west it reached into the vicinity of a CCC camp. A total of 7,998 rodents (7,244 *C. oregonus,* 38 ground-hogs, etc.) have been examined and plague demonstrated in 40; 14 new ranches were recognized as sylvatic plague foci. In the territory covering these ranches 1,110 rodents were examined and *P. pestis* demonstrated in 40 or 3.5 per cent. Over 145 carcasses were picked up and although unfit for examination are gravely suspicious for plague; thus the percentage of diseased squirrels is close to 15 per cent. Only 5 of 67 pools of fleas yielded plague infections in guinea pigs on inoculation.

In the Big Valley District in Lassen County 3 new plague areas were discovered. Again the infection rate was low (0.9 per cent) in the 748 squirrels shot, but since 118 suspected carcasses had been found it is not unlikely that the incidence is closer to 14 than to 0.9 per cent.

Infected fleas have been collected from squirrels, chipmunks, chickarees, etc., in San Bernardino and Placer Counties, although gross anatomical lesions of plague have not been discovered in the 1,900 rodents autopsied in these counties.

Renewed sylvatic plague activity has been noted in Santa Cruz County. In an old focus which was found infected in 1927 and 4 new districts, the epizoötic was quite extensive. The disease incidence varied from 5 to 8 per cent (87 diseased squirrels were found among 1,577 *C. beecheyi* shot within and adjacent to the area). Seven of a total of 28 pools of fleas infected guinea pigs.

In this connection attention is drawn to the interesting fact that despite intensive surveys in the Kern and Tulare areas which were heavily infected in 1934, no diseased squirrels or *P. pestis* carrying fleas were discovered. The available data rather forcibly suggest that a new area may be active for sylvatic plague over a period of 1 to 2 years and then remain apparently silent for 5 to 8 years. Thus the C. Ranch in Santa Cruz County shows the following record:

August 29, 1927—2 infected squirrels
1930, 1931, 1932—Negative findings
1933, 1934, 1935—Negative findings
June 22, 1936—2 infected squirrels
June 26, 1936—8 infected squirrels
June 30, 1936—8 infected squirrels

Although the active suppressive measures may in part be responsible for this behavior, a number of other possibilities deserve further investigation.

2. *Idaho*—The field laboratories of the State Department of Public Welfare and U. S. Public Health Service started surveys on June 2, 1936, and covered 5 western and 5 eastern counties. In 2,119 rodents 27 revealed lesions suspicious of plague. Dr. C. R. Eskey demonstrated *P. pestis* in 108 fleas from 123 *Citellus armatus* shot on one ranch in Bonneville County, June 9–12. Mass inoculations of tissues from 2 *Citellus armatus* shot on June 23 on same ranch proved *P. pestis.* Mass inoculation of material 5 *Citellus armatus* (3 found dead and 193 fleas from 75 squirrels shot at the E. A. Ranch, Bonneville County, Ida., infected guinea pigs and *P. pestis* was isolated.

3. *Montana*—July, 1936, Dr. C. R. Eskey, U. S. Public Health Service, reported that fleas and lice taken from 7 groundhogs (*Marmota*) at the head of Small Horn Canyon, Beaverhead County, infected guinea pigs with typical plague (existence of plague in ground-hogs demonstrated for the first time).

4. *Nevada*—Sylvatic plague has been found in Elko County by inoculating fleas taken from 50 *Citellus oregonus* shot May 7, 1936, on a sheep ranch 8 miles northeast of Lamoille, Nevada. Dr. Eskey reports that the laboratory truck left Nevada shortly after the positive diagnosis of plague was made and did not return until the latter part of June. Therefore, not much work has been done to discover plague in ground squirrels of Elko County.

5. *Utah*—July and August the Public Health Service—Dr. C. R. Eskey—demonstrated plague infection in 1 *Citellus grammurus* found dead in Beaver Canyon, Beaver County, Utah, July 16, 1936; 1 *Citellus grammurus* found dead in Indian Creek Canyon, Beaver County, Utah, July 27, 1936; 315 fleas from 11 *Citellus grammurus* shot 11 miles northeast of Cove Fort, Sevier County, Utah, July 28, 1936; 1 *Marmota flaviventris englehardti* killed with a club in Indian Creek Canyon, 15 miles northeast of Beaver, Beaver County, Utah, July 31, 1936; 2 prairie dogs (*Cynomys parvidens*) shot August 6, 1936, 5 miles northeast of Panguitch, Garfield County, Utah; and 45 fleas from 23 prairie dogs (*Cynomys parvidens*) shot August 7, 1936, on Porter Ranch, 2 miles east of Hatch, Garfield County, Utah.

The survey studies made throughout the western states since 1908 and particularly since 1934 have conclusively proved that the rodents listed in Table I-A suffer from spontaneous plague. Those presumably suffering from spontaneous plague since infected fleas have been removed from their bodies are shown as Table I-B.

Experimentally, the susceptibility of the ground-hog (*Marmota flaviventer*), chipmunk (*Eutamias amoenus amoenus*), Sierra Nevada golden-mantled ground squirrel (*Callospermophilus chrysodeirus chrysodeirus* [Merriam]) and True white-footed mouse (*Peromyscus truei truei* [Shufeldt]) has been established.

The survival (in days after percutaneous (scarification) infections conducted in July and August were as follows:

Control guinea pigs: 4, 4, 5
Oregon squirrels: 4, 4, 5, 5, 3, 6, 6, 6, 5, 10, 1 survived
Chipmunks (*Eutamias*): 3, 3, 3
Sierra Nevada golden-mantled ground squirrels: 3, 3—cannibalism 3, 3
Ground-hogs (*Marmota*): 8, 10, 9, 2 survived
Peromyscus truei: 3, 3

Of interest are the susceptibility tests on ground-hogs made before spontaneous plague had been demonstrated in these rodents. Irrespective of the

TABLE I-A

Rodents that suffer from spontaneous plague:

Sciuridae	Beecheyi ground squirrel	*Citellus beecheyi*
	Oregon squirrel	*Citellus oregonus*
	Utah spermophile	*Citellus armatus* (Nevada and Idaho)
	Rock squirrel	*Citellus grammurus* (Utah)
	Columbia squirrel	*Citellus columbianus* (Oregon)
	Richardson squirrel	*Citellus richardsonii* (Montana)
	Yellow-bellied marmot	*Marmota flaviventris englehardti* (Utah)
	Tahoe chipmunk	*Eutamias quadrivittatus frater* (Allen)
	Utah prairie dog	*Cynomys parvidens*
Muridae	Gilbert white-footed mouse	*Peromyscus truei gilberti* (California)
	Western bushy-tailed wood rat	*Neotoma cinerea occidentalis*
	Intermediate wood rat	*Neotoma lepida intermedia*
	Dusky-footed wood rat	*Neotoma fuscipes*

TABLE I-B

Rodents presumably suffering from spontaneous plague since infected fleas have been removed from their bodies:

Fisher squirrels	*Citellus beecheyi fisheri*
Sierra Nevada chickaree	*Sciurus douglasii albolimatus*

site of infection—abdomen or lower hind legs—the days of survival varied between 8 and 10. The pulmonary involvements were quite extensive, in 1 instance accompanied by numerous intestinal ulcerations due to plague bacilli which doubtless had been swallowed in the tracheal mucous rich with *P. pestis*. Experiments on hibernating Oregon squirrels indicated slightly prolonged periods of survival. Following the usual scarifications, the animals succumbed to septicemic plague in 6 to 8 days. Susceptibility studies on rodents caught in old sylvatic plague foci are too limited to warrant conclusions.

C. VECTOR AND FLEA TRANSMISSION STUDIES

In accordance with the program suggested by Dr. C. R. Eskey, a number of studies have been undertaken. In California an attempt was made to collect large numbers of fleas and test the emulsions of the crushed insects by guinea pig inoculations. The fleas, which have been killed with chloroform, were combed from the cadavers of the wild rodents. They were transferred to physiological salt solution (in summer a 3 per cent salt solution is preferable in order to suppress bacterial growth) and shipped to the laboratory. As a rule, they were washed in sterile salt solution then ground in a mortar. The suspensions were injected subcutaneously into guinea pigs. For the sake of economy large pools of fleas collected from squirrels of a given area were so treated. A total of 338 pools covering 17,588 fleas collected from 6,839 squirrels, 719 rats, 38 groundhogs, 75 chipmunks, and 163 mice have been tested by this new procedure. The following important findings deserve recording:

Modoc County — Active plague area; 5 of 67 pools infected guinea pigs with plague.

115	fleas	from	12	Oregon	squirrels
33	"	"	104	"	"
45	"	"	178	"	"
144	"	"	137	"	"
37	"	"	139	"	"

Monterey County—Pool of 259 fleas from 58 *C. beecheyi* proved infectious.

Placer County—Seven of 73 pools collected from squirrels shot in infected areas contain fleas carrying *P. pestis*. Three pools prepared from 23 lots of fleas induced plague in guinea pigs as follows:

65 fleas from 9 *Eutamias*, 13 *Peromyscus*, 5 *Neotoma*, 1 *Sciurus* and 1 *Callospermophilus*

75 fleas from 8 *Sciurus*, 10 *Callospermophilus*, 5 *Eutamias*, 13 *Peromyscus* and 1 *Neotoma*

22 fleas from 1 chickaree (*Sciurus douglasii*)

San Benito County—On a ranch found infected in 1927 and annually examined for diseased rodents, a pool of 285 fleas selected from a larger collection removed from 122 squirrels proved infectious for guinea pigs.

San Bernardino County—Two of 42 pools carried fleas with plague bacilli. A pool of 104 fleas from 38 *Citellus beecheyi fisheri* infected guinea pigs and a pool of 31 fleas from 24 Fisher squirrels, both from localities in which continued post-mortem examination of rodents had failed to reveal plague, proved to be infected with *P. pestis*.

Santa Cruz County—Seven of a total

of 35 pools of fleas collected from diseased and apparently normal squirrels infected guinea pigs.

Ventura County—One pool of 317 fleas from 23 rodents carried *P. pestis.*

The significance of these results must be emphasized. Without the examination of fleas, the epidemiology of 2 human cases would have remained unsolved and the existence of sylvatic plague in 2 counties would doubtless be unknown. Furthermore, the demonstration of infected fleas on Fisher squirrels and 1 chickaree stigmatizes these 2 rodents as possible spontaneous hosts of plague. As a tool in the course of sylvatic plague surveys, the testing of fleas will prove of inestimable value. The few observations available also indicate that this method of examination will be useful in studying the persistence or disappearance of sylvatic plague from areas in which the disease has been active. It was always suspected that the search for diseased squirrels or other rodents is quite limited since many of the infected animals may rarely leave their subterranean burrows. By a judicious selection of the pools of fleas doubtless more information may be collected. The few promising results amply justify the increased cost and labor which the surveys of the future may entail.

Obviously, the flea surveys must be supplemented by identifications and numerical estimates of the species of fleas which are found on the rodents during the different seasons of the year. In California, a few preliminary attempts have been made with the assistance of Dr. M. A. Stewart, Assistant Professor of Entomology, College of Agriculture, Davis, Calif. Some identifications clearly indicate the complexities which will confront the biologist in determining the plague transmitting capacities of the different species of fleas which may be encountered.

In August, 1936, the Beecheyi squirrels in Monterey County were infested with *Hoplopsyllus anomalus Bak. and Diamanus montanus Bak.* in the proportion 57:68.

In July, 1936, the Oregon squirrels in Modoc National Park were infested as follows: *Oropsylla idahoensis* (Bak.) 71, *Thrassis acamantis* (Roths) 5, *Diamanus montanus* 3, and *Monopsyllus wagneri wagneri* (Bak.) 1.

The classifications of fleas taken from rats caught in Salt Lake City and vicinity during the month of September by Dr. C. R. Eskey disclosed the important fact that *Xenopsylla cheopis* was present in considerable numbers among the insects removed from the rodents caught in the vicinity of the city. Should squirrel plague occur in the areas where these fleas were found, the danger of an epidemic of rat plague would unquestionably be great. Human cases would be much more likely to follow plague infection among the domesticated rats. These and similar observations merely sketch the many potential ramifications which require detailed investigations.

Concerning the ability of these different species of fleas caught on wild rodents to transmit plague to man nothing is known. Already in connection with the discussion of human plague histories collected in 1936, it has been emphasized that the flea appears to play a decidedly subordinate rôle. Again attention should be called to the fact that among the personnel of the survey crews who have for years been exposed to fleas which in the light of the recent observations were infected, no case of plague has been observed. These and similar considerations have prompted Dr. C. R. Eskey, U. S. Public Health Service, to conduct a series of fascinating and promising experiments. Although it is anticipated that he will personally report his far-reaching preliminary findings,

it may not be out of place to mention one fact he so kindly gave me. The squirrel flea—*Hoplopsylla*—will attack man in very rare instances; even bite-transmissions to guinea pigs appear to be very difficult. While "blocking" of the proventriculus of the rat flea—*Xenopsylla cheopis*—is a proven fact and regurgitation of plague bacilli into the bite is the actual mechanism of transmission, Dr. Eskey has shown that in Diamanus "blocking" is not commonly observed; but the fecal droppings are infectious. In all probability the excreta of the insects are principally concerned in the transfer of *P. pestis* from the vector to the rodents and perhaps to man. These newer concepts greatly clarify the epidemiology of sylvatic plague and in part at least explain the very low incidence of human plague, despite the extensive reservoirs which have existed in many regions throughout California and the West. A study of the bionomics of the wild rodent fleas and systematic identifications of the insects found on squirrels in the vicinity of human habitations may furnish data concerning the possible exchange of vectors. That rat fleas may infect themselves on diseased squirrels and thus ultimately bring rural plague to man must be admitted and subjected to experimental inquiry. The problem of infected and infective fleas and the mechanism of transmission influenced by temperature and humidity is only a part of the sylvatic plague problem, but it is, in the judgment of everybody, the most important one, and the committee trusts that Dr. C. R. Eskey will pursue his auspicious researches with every possible assistance that can be given to him. Equally important is the solution of the problem relative to rôle of the vectors not merely as transmitters of infection but in carrying over the disease agent from one plague season to another.

D. BACTERIOLOGICAL STUDIES CONCERNING THE ORIGIN OF PLAGUE IN CALIFORNIA

It is quite generally believed that the West Coast of North America became infected in the course of the pandemic of 1894 which originated in Hong-Kong. Probably rats conveyed the seed to the shores of California and gradually spread it to squirrels, and from squirrel to squirrel the disease has assumed its easterly march as far as Montana. This interpretation of the available facts has received considerable support through comparative bacteriological tests which Dr. K. Kuraichi from the Manchurian Plague Laboratory conducted at the Hooper Foundation. He had previously established the important fact that the plague strains isolated in Manchuria, Mongolia, and Russia ferment glycerine, while those obtained from China, Japan, India, and Italy are unable to utilize this alcohol. While studying 23 recent and old cultures of *P. pestis* isolated in California, he found that they were glycerine negative (Beta type). In comparing the data available for 15 strains studied by Dr. W. M. Dickie and his associates 1924–1925 which were also glycerine non-fermenters, Dr. Kuraichi concluded that these cultures were descendants of the great pandemic strain which has spread to India, Argentine, South Africa, etc., by shipments and that the sylvatic plague of the North American Continent had no connection with similar endemic foci of Transbaikalia, Mongolia, or Southeastern Russia. This interpretation of these bacteriological findings deserves further attention although the impression conveyed by Russian and Japanese workers that glycerine positive strains are confined to Mongolia and East Russia is in part invalidated by the findings of Alpha type in South Africa by Pirie. Dr. Kuraichi's observations are suggestive but not conclusive.