

A Brief History of Bubonic Plague in Hawaii¹

JAMES K. IKEDA²

Today the people of Hawaii enjoy the relative comfort and freedom from vector pest nuisances and fatal vector-borne diseases. This high degree of human comfort and security was achieved through the efforts of the Hawaii State Department of Health's Vector Control Program. It is the purpose of this address to provide you with some of the highlights in the evolution of the present Vector Control Program through a brief summary of the Bubonic Plague episode in Hawaii. The primary sources of information for this address were acquired from the Annual Reports published by the Board of Health (nee: Hawaii State Department of Health) from 1899 to 1960 (Anon. 1899-1960).

FIRST BOARD OF HEALTH IN THE UNITED STATES

In 1836, during the reign of King Kamehameha III, Chief Counselor and Governess of Oahu, Kinau, issued the earliest documented public health measure for Hawaii (Ackland, 1949, and Cunningham, 1959). In this decree, Kinau instructed the Honolulu harbor pilot to "ascertain whether there has been any smallpox or other pestilent disease on board an approaching vessel, and if so, direct the master to hoist a yellow flag at the main and immediately give information to the constituted authority." Her purpose for the decree was to keep Hawaii free of infections originating from other countries and to protect the people of Hawaii, since Honolulu was already recognized as a cross-road of the Pacific. Following her untimely death in 1839 from one of the pestilents she had intended to prevent (mumps and paralysis), a group of private citizens and government agents which included R.C. Wyllie, T.C.B. Rooke, and E.O. Hall, urged the King to establish a Board of Health to insure the protection of the people of Hawaii against the dreaded diseases, smallpox, cholera, and other European and Asiatic diseases as Kinau had wished before her death. Through the concerns of Wyllie, Rooke, and Hall, the Board of Health henceforth referred to as BOH was created on December 13, 1850 by king Kamehameha III, the first Board of Health in the United States.

Almost immediately following the creation of the BOH, an epidemic of smallpox occurred in 1851 in Hawaii. The limited funds originally legislated for cholera-protection were utilized to aid the smallpox victims. The initial epidemic was abated in 1854 through compulsory vaccinations ordered by the BOH. A second epidemic broke out in 1861 and although the BOH was better prepared to handle this epidemic, the epidemic was not quelled until after 282 deaths occurred.

From 1878-1890, the BOH stressed the importance of sanitation as a disease-preventive measure and passed numerous regulations to that effect. Despite these regulations, a cholera epidemic broke out in 1894 (58 years after Kinau's first issued orders to prevent its occurrence) because of manpower shortages to adequately enforce the regulations. Following closely on the heels of the cholera epidemic, on December 12, 1899, the first case of bubonic plague death was announced to the public by the BOH in Honolulu.

¹Presidential Address, presented at the December 11, 1978 meeting of the Hawaiian Entomological Society. Published with the approval of the Director of Health, Charles G. Clark, May 3, 1983.

²Vector Control Branch, Hawaii Department of Health, Environmental Protection and Health Services Division, 2611 Kilihaui Street, Honolulu, HI 96819.

PLAGUE EPIDEMIC OF 1899-1900 (Honolulu)

The first recorded incidence of a vector-borne disease in Hawaii occurred at the close of the nineteenth century. Today (December 11, 1978) marks the 79th year following the original consultative diagnosis of bubonic plague in Hawaii. Yon Chong, a Chinese bookkeeper employed by Wing Wo Tai in the old Chinatown section of Honolulu, became ill on December 9, 1899. The attending physician, Dr. S. Ching, suspected plague because of the buboes formed during the latter stages of the infection. He therefore asked for a jointly conducted diagnosis by Drs. W. Hoffman, G.H. Herbert, F.R. Day, and Carmichael who confirmed his suspicions and reported their findings to the President of the BOH on December 11, 1899. BOH President Cooper made the public announcement on December 12, 1899 of the diagnosis. He immediately placed a strict military quarantine of the Chinatown area and closed the port of Honolulu to incoming and outgoing vessels. A corp of volunteer inspectors were recruited to inspect Chinatown and to ferret additional human cases for isolation as well as to disinfect and sanitize infected premises.

The volunteer brigade of private citizens authorized by the BOH as inspectors started their inspections on December 13, 1899 in hopes of containing plague within Chinatown and hopefully only within Honolulu. The inspectors were charged with the responsibility to locate plague cases and "infected premises" which were then required to be disinfected with 5% sulfuric acid solution and bichloride of mercury and sanitized by destroying the old privy and digging new cesspools.

In hopes of containing plague only within Honolulu, the BOH closed the port of Honolulu to both incoming and outgoing vessels. All foreign ships already docked at the wharf were ordered to move the vessels a minimum of 6 feet away from the dock and grease all mooring lines and attach a funnel (rat-guard) on each mooring line anchored to the shore. All ships having no contact with the shore were required to stay offshore and were declared plague-free as long as no contact was made with shore and no human case of plague developed on board ship within seven days. All shore leaves for mariners and passengers aboard vessels anchored offshore were cancelled and no one on board was allowed ashore. Unloading of said vessels was done via shuttle crafts. Loading of such vessels was under the strict supervision of a BOH inspector who had to check that the on-loading cargo was plague-free. No vessel was allowed to leave Honolulu Harbor without the prior clearance and certification from the Board of Health.

From the onset, three human cases of plague were recorded in the official BOH records. Later examination of other case records showed that in actuality two earlier cases were misdiagnosed and were therefore unrecorded as plague. Inasmuch as no further human cases of plague were detected following the initial episode, the BOH (possibly because of economic pressure) lifted the quarantine of Chinatown and Honolulu Harbor on December 19, 1899, a dramatic error in judgment as was later evidenced.

On December 24, 1899, only five days following the lifted quarantine, the plague epidemic in Honolulu erupted in full force with an additional 9 cases occurring to the end of the year. Thus in a matter of 19 days, a total of 12 cases of plague was diagnosed, leading to 11 fatalities. The Honolulu epidemic was not halted until March 31, 1900 during which time a total of 71 cases of plague was diagnosed, leading to 61 deaths. During this re-emergence of plague, the port of Honolulu was again quarantined until the official reopening on April 30, 1900. In order to maintain business with the neighbor islands and abroad, a group of concerned Honolulu Chamber of Commerce members met and outlined a plan which included rat-

proofing Honolulu wharf and taxing imported goods to defray the cost of rat-proofing the wharf (Hodge and Ferris, 1950). The proposed tax later became known as the quarantine tax and the monies collected not only paid for the cost of rat-proofing Honolulu wharf but enough was collected for future use by the BOH to combat rats and other unbudgeted pestilences which could not be funded by the Legislature.

When plague re-emerged on December 24, 1899 in Honolulu, BOH President Cooper authorized a commission of three (G.R. Carter, C.B. Riply, and Edwards) to investigate conditions in Chinatown and to recommend necessary steps for reconstruction and sanitization of that district. The special commission reported numerous insanitary conditions existing in Chinatown and concluded the report with this statement which reflected the ideologies of that time, "Plague lives and breeds in filth and when it got into Chinatown, it found its natural habitat" (Iwamoto, 1969). On December 30, 1899, the BOH upon recommendations from the special commission as well as from resolutions from the Medical Society and private citizens, chose fire as the final method of plague suppression based on the statement again expressing the existent ideology, "Fire would destroy the plague germs, kill rats, cleanse the soil and open it up to the purifying influences of sun and air, and would prevent any occupancy of the premises until a safe period of time had elapsed." Thus, beginning on December 31, 1899, many sanitary fires were started at the order of the BOH culminating in the great Chinatown fire of January 20, 1900, a phenomenon which many publications attribute as the primary cause of the rapid cessation of the first epidemic in Chinatown. Several references (Iwamoto, 1969 and Eskey, 1934) delineated the extent of the fire and the estimates of the area ranged from 38-65 acres. The fire caused the destruction of all premises bounded by Kukui Street, River Street, Queen Street (presently Ala Moana Blvd.), and Nuuanu Avenue.

Unfortunately, at that time (1899), the only known medical or public health methods of plague control were based on the ancient miasmatic or contagion theories whereby the guiding principle of prevention was to isolate the sick and contacts, and to quarantine and disinfect all infected goods, premises, and ships (Hirst, 1953). The association between rats and plague was recognized far back in history but scientific proof was unavailable till a later date (Service, 1978). Even without the scientific evidence of rat association at that time, the BOH instituted a rat bounty as a means of plague suppression but later changed to rat-trapping and poisoning by a small team of workers funded by the Honolulu Chamber of Commerce to compliment the disinfection and sanitization of premises. In addition, the BOH Bacteriologist autopsied rats caught and found them to be infected with plague-like organisms. Thus a regulation was later enacted to require any resident of the Territory of Hawaii to report any dead rodent to the BOH for retrieval and examination.

SPREAD OF BUBONIC PLAGUE

Following the Chinatown fire of January 20, 1900, cases of plague on Oahu began to appear in other previously uninfected areas and spread as far off as Waialua. The spread of plague on Oahu was traced to the railroad linking Honolulu with the plantation towns of Aiea, Waipahu, and Waialua. The last recorded case of plague on Oahu (a rodent case) was recorded from Aiea in 1910 after which time it has never been found again. Most publications consulted attribute the disappearance of plague on Oahu in 1910 to be from natural causes rather than from the desultory control measures instituted against the rodents.

The spread of bubonic plague to the neighbor islands from Honolulu was quite rapid following the unfortunate lifting of the quarantine on December 19, 1899 of Honolulu Harbor. The island of Maui recorded its first human case of plague on January 30, 1900 in the port town of Kahului. The first human case of plague on the island of Hawaii was recorded on February 5, 1900 in the port city of Hilo.

The island of Kauai recorded its first human case of plague on November 5, 1901, nearly two years following the initial epidemic in Honolulu. Kauai's exposure to plague was the shortest on record, starting in November, 1901 and lasting only until 1902 and was restricted to Kealia, Eleele, and Wahiawa. The total number of human cases recorded for Kauai was 11 cases, all of which were fatal.

The plague episode on the island of Maui was very peculiar. The initial outbreak was in January, 1900 in the port town of Kahului. Immediately, the Chinatown section of Kahului was burnt down leading to the end of detectable plague on Maui until 1931. During the initial outbreak of plague on Maui, a total of 9 fatal cases of plague was recorded. The next official case of plague was not reported until 1931 when a case was diagnosed from Kula. Eskey (1934) believed that plague was not actually eradicated from Maui during the Kahului fire of 1900 but slowly made its way up the slopes of Haleakala as was evidenced by a severe rodent epizootic in 1916 and later by several cases of suspicious illnesses similar to plague in 1926 and again in the fall of 1930 in Makawao. Following the re-emergence of plague in 1931, several sporadic cases of plague infections were detected in humans leading to the last human case recorded in 1938. The last recorded rodent infection on Maui was isolated in 1949 from Makawao-Paia.

Plague on the island of Hawaii was of greatest concern because of the persistence of the disease on that island which could re-infect other plague-free areas in the Territory. Plague was initially detected in Hilo on February, 1900 and rapidly spread from Hilo south to Olaa (Keeau) and north to Laupahoehoe with human cases being recorded in these areas up to May, 1918. By March, 1910, the spread of plague was detected as far off as Honokaa town in the Hamakua District. The Hamakua District encompassing Honokaa was unique in that human plague cases occurred until November, 1949 and plague infections were found in rodents until 1957 despite the tremendous anti-rodent campaigns conducted in these districts by private and governmental workers. The cooperative efforts of anti-rodent work included major works initiated by the sugarcane companies following the anti-rodent research conducted by our deceased member, Dr. C.E. Pemberton in 1923 at Honokaa Sugar Company (Pemberton, 1925 and Bianchi, 1977). The sugar companies were interested in rodent control not only because their laborers were being infected with plague but because of the extensive damage caused by rodents to their sugarcane crops. The BOH during the early years served as the coordinator for these anti-rodent activities and collected the rodents trapped by the plantations for examination.

In 1957, following the last rodent-isolate of plague in Honokaa, the then Rodent Control Branch received a sizeable grant from the U.S. National Institute of Health to conduct a study of plague in Hawaii, more specifically Hamakua District. It was an unfortunate timing for the grant since no natural isolates of plague from rats or humans could be encountered. Numerous studies dealing with some of the basic data on plague ecology and epidemiology were published as a result of the research conducted in Hamakua. The publications included studies on the rodents, flea vector and the etiological agent, and its immunology.

One of the studies left some doubt regarding the existence of plague in the endemic foci of Hamakua which till today has not yet been resolved. The theories of Telluric Plague as well as for Avirulent Plague mentioned by Devick (1968) have clouded the issue. Considering the theories, and the possibilities of recrudescence of plague by these means, no one to date has ventured an opinion that Hawaii is plague-free even after 20 years of negative findings of rodent and mongoose serological examination.

PLAGUE EPIDEMIOLOGY IN HAWAII

Looking back into history, one is often tempted to become excessively critical in view of the modern control methodologies. The review of the old literature available immediately changes the critical attitude to a feeling of deep appreciation for the remarkable work done by the "old-timers."

The epidemiological evidence of human plague cases in the State revealed that two epidemiological forms of plague existed in Hawaii, the urban and rural forms. This rural form of plague found in Hawaii, however, should not be confused with sylvatic plague which is found in the western North American states and which is perpetuated by native wild rodents, especially ground squirrels (*Spermophilus*), and their associated vector fleas (Anderson, 1978). On Oahu, Maui, and Hawaii, the initial outbreaks were classified as urban type of plague which were essentially self-limiting and disappeared naturally. Towards the later stages when cases were no longer epidemic in nature but occurred sporadically, the disease was occurring in agricultural zones where the chance contact between reservoir-vector and man was infrequent. The rural form persisted until it ultimately disappeared or went into a period of quiescence. The persistence of the rural form on the neighbor islands was believed to be perpetuated by a different reservoir-vector complex. It is the writer's belief that the presence of a large susceptible population of the Polynesian rat, *Rattus exulans* (Peale), and its associated flea vector, *Xenopsylla vexabilis* Jordan, played the major role in perpetuating rural plague on Hawaii and Maui.

The types of pathological plague documented by Eskey (1934) in the Hamakua District up to 1933 showed that the primary pathologies were the bubonic plague (83%), while pneumonic plague accounted for 15% and septicemic plague accounted for only 2% of the cases. It is surprising that more secondary pneumonic plague cases did not arise resulting from the exposure to the primary pneumonic cases, and it is believed that the rapid isolation of pneumonic cases and the follow-up quarantine of contacts were the reasons that the pneumonic form did not take a greater toll among the people as it did in California in 1908.

The total number of human plague cases recorded in Hawaii was 410 cases, of which 375 or 91.5% were fatal. The distribution of plague cases is as follows:

Oahu	228 (24 recovered)
Kauai	11 (0 recovered)
Maui	16 (1 recovered)
Hawaii	155 (10 recovered)
Hilo	43 (9 recovered)
Hamakua	112 (1 recovered)
<hr/>	
Total	410 (35 recovered)

It is recognized that the great number of cases of plague in Hawaii as well as for the rest of the world at that time could be attributed to the delayed clinical recogni-

tion of plague by the physicians. In certain instances, the government itself was to be blamed for the enormity of deaths. A prime example of non-recognition by the government was the San Francisco epidemic of plague in 1900 where for at least 3 years the Governor of California refused to believe or recognize the existence of plague in California (Link, 1955). It was later believed that his failure to recognize the existence of plague was for fear that California Products would come under strict quarantine from the rest of the world as well as from the other states.

Hawaii, on the other hand, must be given considerable praise because of the early recognition of plague and the cooperative efforts of government (Territory BOH & U.S. Marine Hospital Services) and the private citizens and businesses, even if the resultant methods utilized were desultory. The methods were desultory in the initial stages because of absence of any scientific proof of rodent-flea associations. Evidence of this reservoir-vector relationship became available only after the extensive work of the Indian Plague Commission which was not published until after 1907 (Meyer, 1947 and Hirst, 1953). Further improvement for plague control became evident as surgeons from the U.S. Marine Hospital Services were assigned to serve as leaders for Hawaii through the difficult years of plague. The flea theory was not generally accepted until after 1915, following the discovery of the mechanism of plague transmission through fleas by Bacot and Martin (Service, 1978), 20 years after Simond first proposed his original flea theory. Mention of flea control as part of plague control was conspicuously absent in early literature and mention of insecticide applications occurred only after DDT became available in the late 1940's.

SUMMARY

During the last pandemic of plague, plague infections were diagnosed for the first time in Hawaii at the turn of the nineteenth century. The probable origin of the infection was traced to the introduction of infected rodents from an infected port in the orient, most probably Hong Kong. The initial infections were typical cases of the classical urban epidemic form of plague, as evidenced by the abrupt onset of numerous cases of infections within a limited foci, and was self-limiting and faded out quickly. This form of plague occurred in Honolulu, Hilo, Kahului, and Elele, the primary port towns on Oahu, Hawaii, Maui, and Kauai, respectively.

In direct contrast to the classical urban form of plague, a rural form of plague persisted on Maui and Hawaii for a significant length of time. The primary reasons for the persistence of rural plague on Maui and Hawaii were postulated by Eskey (1934) and Quan, *et al.* (1965) as: (1) the endemic foci had available large populations of immune reservoir, susceptible reservoir, and the associated vector flea (*Rattus norvegicus*, *R. exulans*, and *X. vexabilis*, respectively); (2) the endemic foci had the proper climatic conditions to sustain plague; (3) rodent control in these endemic foci was very difficult; and (4) insecticides were not available until the use of DDT dusts and sprays during and after World War II (Kartman & Lonagan, 1955).

During the 50+ years in which records of positive evidence of plague were accumulated (isolation of the plague bacillus from rodents, fleas, and human cases), a total of 410 human cases of plague was recorded in the BOH records of which 375 or 91.5% were fatal. It may appear from these past records that the control methods used were desultory. However, concrete evidence as to the roles of rats and fleas in the transmission cycle of this infection were not available until later. Thus, the BOH should be given credit for its early recognition of the dangers of infections from the rats which were examined from the beginning at the BOH Laboratories.

ACKNOWLEDGMENTS

The author wishes to thank Ms. Gladys Lee, Secretary to the Director of Health, and Ms. Marion Akamine, Health Educator, for helping him locate the old Board of Health Annual Reports used as the reference base for this historical review. The author also wishes to thank the Department of Health's Publication Review Committee Members for their critical review and suggestions to this manuscript: Thomas A. Burch, M.D., MPH, Chief, Research and Statistics Office; Dennis G. McLaughlin, Ph.D., Head, Research and Evaluation, Mental Health Division; and Ms. Christine Ling, Chief, Health Promotion and Education Office.

REFERENCES CITED

- Ackland, R. 1949. A century of public health in Hawaii. Office of Health Education, Department of Health, Territory of Hawaii. 17 pp.
- Anderson, E.T. 1978. Plague in the continental United States, 1900-1976. Public Health Reports, 93(3):297-301.
- Anon. 1899-1930, 1933-1960. Annual Report of the Board of Health, Territory of Hawaii.
- Bianchi, F.A. 1977. Cyril Eugene Pemberton, 1886-1975. A biographical sketch. Proc. Hawaii. Entomol. Soc. XXII (3):417-441.
- Cunningham, C. 1959. History of public health in Hawaii. In: Annual Report, Department of Health, 1959. 11 pp.
- Devick, W.S. 1968. Rodent plague in Hawaii. Proc. — Rodents as factors in disease and economic loss. Asia-Pacific Interchange, Honolulu, June 17-27, 1968. (pp. 137-145)
- Eskey, C.R. 1934. Epidemiological study of plague in the Hawaiian Islands. Public Health Bull. No. 213, 70 pp.
- Hirst, L.F. 1953. *The Conquest of Plague*. Oxford. Clardon Press. 478 pp.
- Hodge, C.L. and P. Ferris. 1950. *Building Honolulu. A Century of Community Service*. Chamber of Commerce of Honolulu. Honolulu, Hawaii. 110 pp.
- Iwamoto, L. 1969. The plague and fire of 1899-1900 in Honolulu. In: *Hawaiian Historical Review*, Hawaiian Hist. Soc., II(8):122-143.
- Kartman, L. and R.D. Lonegan. 1955. Wild rodent-flea control in rural areas of an enzootic plague region of Hawaii. Bull. WHO, 13:49-68.
- Link, V.C. 1955. A history of plague in the United States. Public Health Monograph, No. 26, 120 pp.
- Meyer, K.F. 1947. Plague. In: *Diseases transmitted from animals to man*, by T.G. Hull. C.C. Thomas Publisher, Springfield, Illinois. (pp. 323-350)
- Pemberton, C.E. 1925. The field rat in Hawaii and its control. HSPA Expt. Sta. Entomology Series Bull. No. 17, 46 pp.
- Quan, S.F., C.M. Wheeler, M.I. Goldenberg, and L. Kartman. 1965. The susceptibility of *Ratus* species from two areas of Hawaii to infection with *Pasteurella pestis*. Amer. J. Trop. Med. Hyg. 14:638-642.
- Service, M.W. 1978. A short history of early Medical Entomology. J. Med. Ento. 14:603-626.