CURRENT STATUS OF PLAGUE AND PLAGUE CONTROL IN THE UNITED STATES

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ABSTRACT: During the first quarter of the 20th century massive rat-borne plague epidemics occurred in port cities of the United States in conjunction with the last world-wide pandemic which originated in China in 1893. By 1950, plague was found to be firmly established in wild rodent populations in states west of the 100th meridian. Presumably because of improved sanitation coupled with retreat of the world-wide pandemic there have been no human cases in this country associated with urban rats since 1924. However, sporadic cases, fewer than 10 per year, are reported as due to contact with wild rodents, lagomorphs, rural rats, and/or their fleas.

Recent observations suggest that: a) in the current decade there has been an increase in human plague cases; b) there continues to be a serious potential of a single undiagnosed and untreated case, which possibility is intensified by the very paucity of human cases decreasing the likelihood of a correct diagnosis and by changing patterns of life exhibited by members of our society (e.g., hippie communes and a generally increased mobility); and c) the apparent distribution of plague only in the area west of the 100th meridian might be found to represent an unrealistic generalization if adequate surveillance were carried out.

At the present time human plague cases from wild animal sources tend to be isolated events both spatially and temporally and often cannot be attributed to confined and definable epizootic sources amenable to effective control programs. Improved means for epizootic control and long term management of enzootic plague sources must be sought aggressively. These measures should include development of: a) a surveillance network to detect plague activity in rodent and lagomorph populations throughout the western United States; b) effective, yet ecologically sound, means of ectoparasite control, including suitable materials and methods of application; c) methods for management of plague-susceptible wild animal populations, particularly where they exist in contact with high use recreation and residential areas; and d) more extensive knowledge of enzootic plague and the factors that bring about epizootic plague and potential human contact.

Introduction:

Plague was not described or recognized as a natural infection of man or rodents in the continental United States prior to the 20th century. Whether or not Yersinia (Pasteurella) pestis was introduced as an extension of the latest pandemic originating in Asia about 1893, the organism is presently firmly entrenched in the wild rodent population of western North America from Kansas to the Pacific coast and the Mexican border to Canada. Y. pestis has never been found in Alaska and has not been isolated in the State of Hawaii since 1957.

The plague bacillus is frequently detected close to major urban centers and undoubtedly occurs in such areas considerably more often than is documented. There are no conceivable means of eradicating rural plague or of eliminating the hazard of its being introduced into an urban setting if urban populations of susceptible mammals are allowed to develop. There also continues to be a possibility that plague infected rats may reach our cities via cargo from other endemic areas such as southeast Asia. This hazard should now be negligible as far as cargo from South Viet Nam is concerned if the pretreatment program instituted in 1969 is strictly adhered to.

Urban Plague:

Since 1924, no cases have resulted from exposure to urban rats and only one case was exposed in an urban setting. In the past decade there have been several isolated observations, however, which indicates the hazard of urban murine plague persists. From 1942 to 1944 rat epizootics occurred in Tacoma, Washington but no human cases resulted possibly due to the fact that the oriental rat flea (Xenopsylla cheopis) was not present. In 1963, a single Alexandrine rat, found dead in the marina district of San Francisco, was infected with plague. In 1964 the transfer of plague infection from a meadow vole population to neighboring Norway rats was detected near a study site area outside San Francisco, California (Kartman, 1966). In 1967 a rat, taken from a ship returning from southeast Asia was fluorescent antibody positive for Y. pestis. In 1968 a human bubonic plague case in Denver, Colorado tipped investigators to an extensive plague epizootic among urban fox squirrels (Sciurus niger). If a successful rat control program had not been in existence in Denver

prior to the squirrel epizootic the stage would have been set for a potentially deadly development. Undoubtedly, the decline of and continued relief from urban plague in this century has resulted, in large part, from the adherence to improved sanitary practices and control of domestic rat populations in urban areas and on board ships involved in inter-continental transport.

Human Plague from Sylvatic or Wild Animal Sources in the United States:

Caten, et al, (1968) reviewed 115 human plague cases associated with rural exposure from 1900 through 1966. Since that reporting, a serologically presumptive case of plague was added to the 1965 list, and 11 cases were reported from 1967 through 1969 making a total of 127 cases associated with rural or wild animal exposures. One case resulted from an urban exposure associated with an extensive fox squirrel plague epizootic in Denver, Colorado in 1968. Although this exposure occurred in a major population center, the epidemiological implications were not the same as that of classic urban murine plague.

Since 1950, nearly 90 per cent of plague cases have been reported from the Rocky Mountain States contrasting sharply with the early part of this century when most cases with sylvan exposure were reported from the Pacific States. In the past five years, 24 cases were reported, most of which occurred in New Mexico (Tables 1 and 2). Cases were also reported from Colorado, Arizona, Utah and Idaho. In 1969, animal plague was demonstrated in Arizona, California, Colorado, New Mexico, Texas, Utah and Wyoming; only one of which (New Mexico) reported human plague. The paucity of cases in California during the past decade may well indicate the merit of the criteria upon which control efforts have been based (Murray, 1964). Since no great strides or changes in our technology have been realized in the past 10 years we should become alarmed if support of these surveillance and control operations in the state are curtailed particularly since the effect of any curtailment will most likely not become immediately apparent.

As evidenced from our experience of the past 55 years, human plague cases from wild animal sources tend to be sporadic, isolated events both spatially and temporally. The small number of cases reported annually in the United States is not an indication of the importance of this disease. A single untreated bubonic case if spontaneous recovery or death do not intervene, may develop a secondary pneumonia and initiate an epidemic of pneumonic plague. With modern means of travel the person may develop his illness thousands of miles from the site of his exposure. There are an inestimable number of missed cases of plague; some, such as Case 20, Table 1, inadvertently receive specific therapy and survive to be detected in retrospect by serological means. Due to their unique habits and philosophy plague among "hippies" constitutes a particularly serious epidemiological hazard.

About one-fourth of the human cases of sylvan origin in this country have been associated with epizootics among small mammals such as sciurids, lagomorphs or feral murine rats. Intimate contact with wild rodent habitat has been a regular feature except for the single urban case in 1968. Contact occurred in such activities as hunting for food or sport, children handling or playing with dead or sick animals, and professional contacts of trappers, veterinarians and taxidermists. Many cases for whom a strong association with proven wild animal plague activity could not be made, had made trips into wilderness areas and occasionally reported skin lesions suggestive of insect bites distal to the regional lymphadenopathy typical of bubonic plague.

A wide variety of mammals have been shown to be infected with Y. pestis in nature. Many, but not all of these have been associated with human cases. Naturally infected mammals include several species of ground squirrels (Spermophilus sp. formerly Citellus), woodrats (Neotoma sp.), whitefooted mice (Peromyscus sp.), prairie dogs (Cynomys sp.), chipmunks (Eutamias sp.), harvest mice (Reithrodontomys sp.), cotton rats (Sigmodon sp.), feral domestic rats (Rattus sp.), cottontail rabbits (Sylvilagus sp.), jack rabbits (Lepus californicus), marmots (Marmota sp.), grasshopper mice (Onychomys sp.), kangaroo rats (Dipodomys sp.), meadow voles (Microtus sp.), sage brush voles (Lagurus curtatus), and fox squirrels (Sciurus niger). A single snowshoe hare (Lepus americanus) was epidemiologically associated with the fatal infection of an Idaho hunting guide in 1968, but no laboratory proof of infection of this mammal was obtained.

Plague Control in the United States:

A consideration of procedures for "plague control" and for "wildlife management" too often engenders thoughts of quite differing natures. Our ignorance of the ecology, distribution and fluctuations of natural plague has prevented our completely closing the gap between these disciplines. As we acquire information on the ecology of the zoonoses, control of these

diseases, including plague, will logically become an integral part of wildlife management. Man will then have taken a decisive step toward learning to live in equilibrium with his environment.

Table 1. Cases of Human Plague Reported in The United States, 1965-1969

Case	Age	Sex	Onset	County and State	Probable Source	Outcome
1	3	F	6/65	McKinley, New Mexico	Prairie Dog	Recovered
2	2	M	7/65	McKinley, New Mexico	Prairie Dog	Recovered
3	3	F	7/65	McKinley, New Mexico	Unknown	Recovered
4	9	M	8/65	McKinley, New Mexico	Prairie Dog	Recovered
5	4	F	8/65	McKinley, New Mexico	Prairie Dog	Recovered
6	3	F	8/65	McKinley, New Mexico	Prairie Dog	Recovered
7	14	M	8/65	McKinley, New Mexico	Prairie Dog	Fatal
8	5	M	9/65	Shasta, California	Ground Squirrel	Recovered
9	5	M	5/66	San Juan, Utah	Uncertain	Fatal
10	72	M	6/66	Rio Arriba, New Mexico	Ground Squirrel ?	Recovered
11	7	F	7/66	Navajo, Arizona	Uncertain	Recovered
12	39	F	7/66	Santa Fe, New Mexico	Wild Rodent Flea	Recovered
13	14	F	7/66	San Miguel, New Mexico	Wild Rodent Flea ?	Recovered
14	4	M	6/67	Coconino, Arizona	Prairie Dog ?	Recovered
15	12	M	7/67	Elbert, Colorado	Prairie Dog	Fatal
16	60	M	9/67	Rio Blanco, Colorado	Uncertain	Recovered
17	6	F	6/68	Denver, Colorado	Tree Squirrel	Recovered
18	8	F	7/68	Navajo, Arizona	Uncertain	Recovered
19	32	M	9/68	Lemhi, Idaho	Snowshoe Hare	Fatal
20	20	F	5/69	Sandoval, New Mexico	Uncertain	Recovered
21	18	M	6/69	Sandoval, New Mexico	Pinon Mouse ?	Recovered
22	3	M	6/69	Sandoval, New Mexico	Chipmunk	Recovered
23	13	F	9/69	Los Alamos, New Mexico	Unknown	Recovered
24	15	M	10/69	Bernalillo, New Mexico	Unknown	Recovered

Plague control must be oriented toward preventing human plague cases and to reducing the potential for human exposure to wild rodent plague. The primary preventive or suppressive measures against urban rat plague consist of rigorous environmental sanitation to reduce or eliminate urban rodent populations. In this and other countries where standards of sanitation are high, large numbers of human bubonic plague cases are virtually impossible. However, since plague continues to exist throughout the world and is firmly entrenched in wild rodent populations in the western United States, uncontrolled urban rat populations are a hazard wherever they exist. Due to the limited geographic areas involved and the consider-

able health organization in urban areas, prevention or control of urban rats or rat plague is feasible and appropriate measures have proven successful.

Table 2. Plague Cases - United States

Year	Arizona	California	Colorado	Idaho	New Mexico	Utah	Totals
1959		2	1		1		4
1960					2		2
1961					3		3
1962							0
1963	1						1
1964							0
1965		1			7		8
1966	1				3	1	5
1967	1		2				3
1968	1		1	1			3
1969					5		5
Totals	4	3	4	1	21	1	34

Current measures for the prevention of sporadic human plague cases consist of (a) public education of persons living or traveling in endemic areas; (b) maintaining surveillance of susceptible mammal populations, particularly when they exist near known or suspected permanent plague foci or near human habitat in western United States; (c) insecticidal measures directed against ectoparasite vectors where potential human exposure is considered to be greatest; (d) local management such as reduction or selective elimination of mammalian populations hazardous to public health, and (e) regulation of hunting and other recreational activities to avoid high risk seasons, areas or animals. These measures, applied on a broad scale, should be concomitantly directed toward prevention of a variety of zoonoses such as tularemia, rabies, rickettsioses, and tick fever as well as plague. It is particularly important to initiate preseasonal education programs on these diseases, not only to reduce the chances of human exposure, but also to prevent panic when plague activity is detected and an intensified control program is implemented.

Insecticidal measures against fleas are the primary means used to prevent or control active plague epizootics in areas where the risk of human exposure exists. Major efforts are concentrated on abundant host-ectoparasite populations most likely to result in human exposure. The methods of insecticidal application depend largely on the habits of the rodent species involved. Fleas on large, colonial burrowing rodents such as prairie dogs (Cynomys sp.) and California ground squirrels (Spermophilus beecheyi) are best controlled by application of insecticidal dust to burrow entrances. Recent field trials conducted by our laboratory have shown that 2% BHC or 2-3% carbaryl are highly effective (Bennington 1970, Barnes 1970). Dust may be applied by a variety of back-pack dusters or thrown into the burrow entrance from a small container. One treatment of 85-100 gms. of 2% carbaryl (1.7 - 2.0 grams active toxicant) per burrow was sufficient to totally eliminate fleas in one treated area from August 6, 1969 to the end of the summer observation period (91 days) (Barnes, 1970).

Against fleas on non-colonial rodents, insecticide bait stations, described by Barnes and Kartman (1960), have been found effective. This method has particular application in recreation areas or in semi-urban situations. Rodents are attracted to stations where they treat themselves with insecticidal dust while taking bait.

Area treatment has been used against fleas on rodents which live in dense, widespread populations and which do not make readily apparent burrows. Application of insecticidal dust may be accomplished by power duster or similar apparatus. This method frequently is ineffective due to field conditions and other variables beyond the control of the operator.

Since a human plague case is often our first indication of wild rodent plague activity in many areas, the major effort for plague control in the past has been to limit additional human exposure or to prevent spread of human or rodent plague into high use recreation areas or population centers. Such emergency plague control, although essential, is not a satisfactory approach. Under such circumstances measures adequate to protect public health or insure that additional cases will not occur often result in use of insecticides to an unsatisfactory degree. It is imperative that measures, other than the extensive use of biological poisons, be sought and perfected for long term management of zootic plague sources and for epizootic prevention or containment. Such measures should include (a) an adequate surveillance network to anticipate or detect epizootic plague activity among rodent and lagomorph populations; (b) effective, ecologically sound, means of ectoparasite control including suitable materials and appropriate methods of application; (c) methods for management of plague susceptible wild animal populations particularly where they exist in contact with high use recreation and residential areas, and (d) more extensive and detailed knowledge of enzootic plague and the factors that precipitate epizootic plague and potential human contact.

LITERATURE CITED

1. KARTMAN, L., GOLDENBERG, M. I., and HUBBERT, W. T. 1966. Recent observations on the epidemiology of plague in the United States. Amer. J. Public Health 56: 1554 and 1569.
2. BARNES, A. M., OGDEN, L. J., and CAMPOS, E. G. 1970. Efficacy of carbaryl dust for flea control in a prairie dog colony. Proposed for the California Vector Views.
3. MURRAY, K. F. 1964. The evolution of plague control in California. Second Vertebrate Pest Control Conference: 143 and 149.
4. CATEN, J. L., and KARTMAN, L. 1968. Human plague in the United States 1900-1966. Journ. Am. Med. Assn. 205: 333 and 336.
5. BARNES, A. M., and KARTMAN, L. 1960. Control of plague vectors on diurnal rodents in the Sierra Nevada of California by use of insecticide bait boxes. J. Hyg., Camb. 58(347): 159 and 167.
6. BENNINGTON, E. E. 1970. In preparation to be published.