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THE CURRENT STATUS OF PLAGUE IN CALIFORNIA

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At the first Vertebrate Pest Control Conference in 1964, I traced the history of plague control in California and outlined a revised approach, based on newer concepts of plague ecology. In our state of relative ignorance, this required a number of unproved assumptions about plague occurrence in California that verged on crystal ball gazing. These were principally that (1) plague persists in relatively resistant rodent species in certain favorable locations, (2) ground squirrels and chipmunks experience periodic epizootics, but are not permanent reservoirs, (3) plague "foci" of the past were merely sites of conspicuous epizootics, they did not necessarily correspond to permanent foci, and could result from epizootic migrations over considerable distances, and (4) a number of assumptions about areas of greatest epizootic potential can be made by analyzing the pattern of recurrent plague outbreaks in the past.

Since then the validity of these assumptions has been tested by the largest outbreak of plague since the early 1940's. We believe that the results have proved the crystal ball largely correct, resulting in much more precise and efficient epizootic surveillance and deployment of control measures than in the past.

The outbreak was for us an administrative emergency that exceeded the capacities of the State Health Department. We greatly appreciated the vital help and cooperation of other agencies and individuals. The U.S. Public Health Service accepted a heavy burden of laboratory testing through its San Francisco Field Station, and provided emergency field personnel. The contributions of State Department of Agriculture, Bureau of Weed and Vertebrate Pest Control; U.S. Parks, Forest Service and Bureau of Land Management; local health and agriculture department; and State Division of Parks personnel were essential in accomplishing control work, as well as epizootic surveillance.

Plague in 1965

The first evidence of the current plague cycle was an infected chipmunk found early in August, 1965, on the north shore of Lake Tahoe (Nevada). Surveys showed that in California, chipmunks and golden-mantled ground squirrels had been decimated over much of the watershed above Kings Beach and in a smaller area above Tahoe City.

In September, 1965, a human plague case occurred at Viola, southeastern Shasta County. Signs of an intensive epizootic of California ground squirrels were found in the area and at Shingletown dump, about seven miles west.

Plague in 1966

In April, 1966, plague was confirmed in 3 wood rats (*Neotoma fuscipes*) found dead at California Hot Springs, in the Tulare County foothills. Upon investigation, wood rats were found to have died off over a wide area. New reports and wide-ranging surveys then revealed that wood rats were being heavily decimated by plague epizootics over most of the upper foothill belt of the southern Sierra Nevada. At several locations, California ground squirrels (*Citellus beecheyi*) were found to be involved.

By late spring, plague was detected in chipmunks and golden-mantled ground squirrels collected by commercial trappers in Shasta and Mono counties. This led to an emergency quarantine on rodent trapping in known epizootic areas. Regulations were revised to require registration of commercial trappers and enforce quarantine and insecticide dusting of captured animals.

Although some evidence was found of chipmunk disappearance in Mono County, no pattern of substantial decimation could be detected.

At Lake Tahoe, further investigation revealed there had been substantially wider decimation in the northwest Tahoe-Truckee River area in 1965 than previously was recognized. But the epizootic apparently subsided in 1966; one infected ground squirrel was obtained near Alpine Meadows.

In Shasta County, intense epizootic activity spread outward from the centers at Viola and Shingletown dump through the summer, extending south to Tehama County. Mice (*Peromyscus*) as well as ground squirrels and chipmunks were involved. An infected chipmunk was found in Lassen Park, but no signs of an epizootic were found in the course of massive surveys.

As anticipated, by July plague had spread upward from the foothills and decimated forest rodents over wide areas in the southern Sierra Nevada. Those areas most conspicuously affected were around Shaver Lake, Fresno County, and Grant Grove, Tulare County. In August, a plague-infected golden-mantled ground squirrel was found at Edison Lake, in the high Sierra of Fresno County; only localized epizootic activity was apparent.

There were isolated positive findings from several localities; a *Citellus beecheyi* from the Tejon Ranch, at the northern base of the Tehachapi Mountains; a *Peromyscus californicus* from the ridge immediately north of San Luis Obispo; an eastern fox squirrel (*Sciurus niger*) from Palo Alto.

Altogether, 58 mammal tissues or flea pool specimens were found positive for plague in 1966, involving 13 mammal species. Evidence of infection was concentrated in two periods—April-May and July-August, corresponding to the peak epizootic periods in the foothills and forested zones respectively. Mammals found sick or dead, most of them submitted by cooperating field observers, were especially valuable. Plague was found in 14.8% of these specimens.

Imported Plague in Shasta County

All evidence showed that plague was brought into Shasta County in 1965 through the activities of a commercial rodent trapper. The die off at Viola apparently developed from two squirrels he trapped near Poison Lake in western Lassen County and gave to a Viola resident. These soon died and were deposited on a dump about one mile away. California ground squirrels on the dump—and in the intervening area had died off. It appeared that the small boy who contracted plague was exposed to infected fleas around a sand pile at Viola where he played. Mummified plague positive squirrels were found nearby. Working outward from this epizootic center, signs of decimation were more recent, and normal populations could be found at the perimeter in all directions.

A second, and separate, site of intensive ground squirrel die off was discovered at Shingletown dump, about seven miles west of Viola. This dump immediately adjoined the headquarters of the commercial trapper.

In 1966, the pattern of outward epizootic spread from the two centers further confirmed the belief that plague was imported into the area. An infected chipmunk found near Eagle Lake, Lassen County, proved that plague was circulating within 30 miles of where the original incriminated animals were trapped.

The Role of Wood Rats

We had earlier suspected that wood rats could play a critical role in the epizootic spread of plague. At the first indication of their current involvement, strong emphasis was placed upon investigating wood rat populations. The stick lodges of *Neotoma fuscipes* were checked for current occupation by examining the freshness of food cuttings and other signs, often supplemented by trapping.

Thus it was found that in mid-April around California Hot Springs, 63 of 68 wood rat lodges had been abandoned for periods estimated from one week to more than a month. This degree of decimation was typical of much of the woodland-Chaparral belt in the southern Sierra, from Fresno through Tulare counties, and in the upper Kern River-Lake Isabella area of Tulare and Kern counties. There was a mosaic of greater and lesser-aged abandonment interspersed with populations not yet affected. The longest abandoned lodges (3 months or more) were found at higher elevations, while wood rats in the low foothills generally were unaffected. Evidence later was found of major wood rat decimation more widely in the southern Sierra, in the Tehachapi Mountains, and in the mountains of northern Ventura County. More recently we have discovered old signs of disappearance in coastal uplands from San Mateo County to Monterey County.

It appears that wood rats have played a critical role in the spread of epizootic plague

in the past. In 1934 a major epizootic in ground squirrels occurred in the Sierra foothills of Tulare and Kern counties. Again, in 1941 there were violent epizootics in 5 separate areas of the southern Sierras and Tehachapi Mountains. No ground squirrel plague was found in intensive surveys during the intervening years. Outbreaks were observed to begin at higher elevations and move downward.

It is clear that plague die offs of wood rats similar to the present pattern would supply the cause of these historical events. And there can be little doubt that if ground squirrels last year were present in the massive numbers of the past, history would have been repeated.

Elsewhere in California, the historic pattern of epizootics in ground squirrels strongly suggests that, at least in the lowlands, prior outbreaks in wood rats probably were responsible for their initiation.

Epizootic Migrations

Earlier we had suggested that permanent reservoirs of plague would be found on the east side of the Sierra and that past occurrences on most of the west slope were a result of periodic epizootic migration over the summit. Prime examples were epizootics at Shaver and Huntington lakes, Fresno County, in 1937, and Edison Lake in 1959.

Current events have supported these beliefs. For example, last year plague decimated forest rodents around Shaver Lake and could be linked with the die off in wood rats that had extended northward in the foothills. In late summer infection was detected at Edison Lake, high in the Sierra. But no sign of animal die off could be found in the intermediate area around Huntington Lake. The Edison Lake finding appeared traceable to the extension of plague activity from Mono County westward across the summit. To test the possibility, evidence of an epizootic pathway was sought high in the drainage of the San Joaquin River. There, to be sure, a sizeable area of ground squirrel and chipmunk disappearance was found. Plague circulation in Mono County caused little decimation of ground squirrels and chipmunks. This suggests their populations have acquired genetic resistance resulting from repeated contact with an enzootic reservoir.

Control Measures

Protective measures in areas threatened by epizootics consisted exclusively of flea control in campgrounds or comparable areas of concentrated human activity. DDT dust was applied directly to rodent burrows and trails or placed in dust-bait stations visited by the animals.

There was evidence that these measures were successful. In numerous dusted campgrounds, ground squirrels and chipmunks later were found to be abundant while populations in the surroundings had been decimated.

Coffee Camp, in the Tulare County foothills, affords a graphic example of the success of the methods. Two dead wood rats were found a few days before a 3-day holiday and the prospect of full camp. California ground squirrels were very abundant and dusting of their burrows was initiated immediately. On the day this was done, clusters of several abandoned burrows and a plague-infected dead squirrel were found. However, the incipient epizootic was halted and camp squirrels remained numerous in the months following.

Insecticide dusting was performed where the epizootic potential was predicted to be high. This was based on initial positive results, evidence that host populations were abundant, and the kind of assumptions about plague ecology that were discussed earlier. As a result, protective measures were applied preventively to a far greater degree than has been achieved in the past. In retrospect, we believe the predictions were valid enough that the area treated corresponded well to the extent of hazard that became evident.

