

Detection of Plague by Testing Serums of Dogs on the Navajo Reservation

WILLIAM S. ARCHIBALD, M.S., and STEPHEN J. KUNITZ, M.D.

THE PRESENCE of plague in wild animal populations often is not discovered until a case occurs in man. Frequently, a diagnosis of human plague is not considered until after the patient recovers or dies. This is particularly true when cases of human plague occur in areas where zootic plague has not been previously noted (1). Knowledge of the proximity of wild rodent plague should contribute to earlier consideration of human plague as well as establishment of criteria necessary for control of the zootic source. Recent studies of rodents and carnivores have shown that serologic studies for plague antibodies in these populations may be used to locate infection in wild mammals (2).

As early as 1722, it was known that dogs are occasionally infected fatally with *Yersinia pestis* (3-7). Only since serologic methods have been commonly used has there been evidence indicating that frequently dogs are nonfatally infected.

In May 1966 the National Communicable Disease Center and the Division of Indian Health of the Public Health Service began a program of plague surveillance and control on the Navajo Indian Reservation. On this reservation, it was discovered that the domestic dog forages for food in much the same manner as a wild mammal, and a pilot project was initiated to evaluate the testing of dog

serums for indicators of wild animal plague. This was done in an area around Tuba City, Ariz., where no human plague had been reported but where, based on scattered reports, wild rodent plague was presumed to be widespread.

Our report submits evidence that, under conditions prevailing on the Navajo Reservation, testing of serums from domestic dogs (*Canis familiaris*) for plague antibodies can provide useful information concerning zootic plague activity.

Methods

In September 1966 and March, May, July, and August 1967, free rabies vaccination clinics were held at trading posts and chapter houses on the Navajo Reservation. A chapter house is comparable to a county seat. The clinics were evenly distributed over a 6,000-square-mile area around Tuba City. Each dog owner was asked to allow a blood sample to be drawn from the radial vein of the dog's leg. Although none of the dog owners refused this, a few dogs were rejected because they were too wild to be handled safely without anesthesia. The sex of the dogs was unavoidably biased because 90 percent of those brought into the clinics were males. No blood samples were taken from the juveniles under 6 months old, nor were they given rabies vaccine.

In addition to taking blood samples from dogs at the rabies clinics, samples were also drawn from people during epidemiologic investigations of human plague.

The serums were transported frozen to the San Francisco Field Station, now relocated in Fort Collins, Colo., and known as the Zoonoses Section of the Ecological Investigations Program, Center for Disease Control. The serums were examined for antibody by the passive hemagglutination test, using *Y. pestis* Fraction 1 antigen.

Results

The locations where plague activity was demonstrated from 1966 through 1968 by canine serum

Mr. Archibald is a public health biologist assigned to the Zoonoses Section, Ecological Investigations Program, Center for Disease Control. Dr. Kunitz is a graduate student at the department of sociology, Yale University, New Haven, Conn. During the time of the fieldwork for this study the authors were in Window Rock, Ariz. Mr. Archibald was with the Zoonoses Section and Dr. Kunitz was a field medical officer for the Division of Indian Health, Navajo Area Indian Health Service, assigned to the Public Health Service Indian Hospital at Tuba City, Ariz. Tearsheet requests to William S. Archibald, Ecological Investigations Program, Center for Disease Control, P.O. Box 551, Fort Collins, Colo. 80521.

surveys are shown in the map. In addition to rabies clinics at all the sites shown, investigations of human cases of plague were undertaken at Oljato, Kayenta, Shonto, and White Mesa. Seropositive dogs were found at eight of the 11 rabies clinics, and plague-positive dogs were also found at three of the four sites where human plague may possibly have been contracted (table 1). Data on individual dogs that were seropositive for plague are presented in table 2.

Discussion

From 1959 through 1966, domestic dogs with antibodies to *Y. pestis* were found to be associated with seven cases of human plague in Navajos (table 3). Available evidence suggests that dogs are highly resistant but not refractory to plague infection. Also, in 1968 the plague organism was isolated from a pool of fleas (*Pulex irritans*) taken from the household dogs of a person with plague (table 1).

Table 1. Domestic dogs examined during investigations of human plague and at rabies clinics for serologic evidence of past infection with *Yersinia pestis*, Navajo Reservation, Arizona

Location	Date	Number dogs	Number positive
Human plague investigations			
Shonto ¹	July 14, 1966	4	2
Shonto ²	Aug. 7, 1966	30	2
Oljato ³	Sept. 1, 1966	3	2
White Mesa ⁴	June 28, 1967	4	0
Kayenta ⁵	July 24, 1968	4	0
Rabies clinics			
Cow Spring.....	Sept. 14, 1966	18	0
Tonalea.....	do.....	11	2
Kaibito.....	do.....	17	2
Cedar Ridge.....	Jan. 15, 1966	5	0
Cameron.....	do.....	16	1
Cameron.....	May 11, 1967	25	1
Rough Rock.....	Mar. 28, 1967	1	1
Coal Mine.....	May 12, 1967	12	1
Dennebito Dam.....	do.....	19	2
Tuba City.....	do.....	78	1
Copper Mine.....	July 26, 1967	10	1
Tsegi.....	Aug. 4, 1967	9	0
Total.....		266	18

¹ Hogan of plague victim, 10 miles from Shonto—the nearest town.

² Visited by plague victim during possible exposure interval.

³ Hogan of patient who died of plague.

⁴ Hogan of plague patient.

⁵ Hogan of plague patient. Flea pool (*Pulex irritans*) from these dogs were plague positive.

Table 2. Passive hemagglutination titers to *Yersinia pestis* of 11 male dogs and 1 female dog, Navajo Reservation, 1966–67

Arizona location	Date	Age	Titer
Tonalea.....	Sept. 14, 1966	6 months...	1:64
Do.....	do.....	1 year.....	1:256
Kaibito.....	do.....	2 years.....	1:1024
Do.....	do.....	1 year.....	1:512
Cameron.....	Sept. 15, 1966	8 months...	1:512
Rough Rock.....	Mar. 28, 1967	5 years.....	1:64
Cameron.....	May 11, 1967	8 years.....	1:64
Tuba City.....	do.....	13 years.....	1:16
Coal Mine.....	May 12, 1967	3 years.....	1:8
Dennebito Dam.....	do.....	do.....	1:8
Do.....	do.....	2 years ¹	1:4096
Copper Mine.....	July 26, 1967	10 years.....	1:16

¹ Female.

Table 3. Serologic evidence ¹ of prior *Yersinia pestis* infection in dogs associated with human plague cases

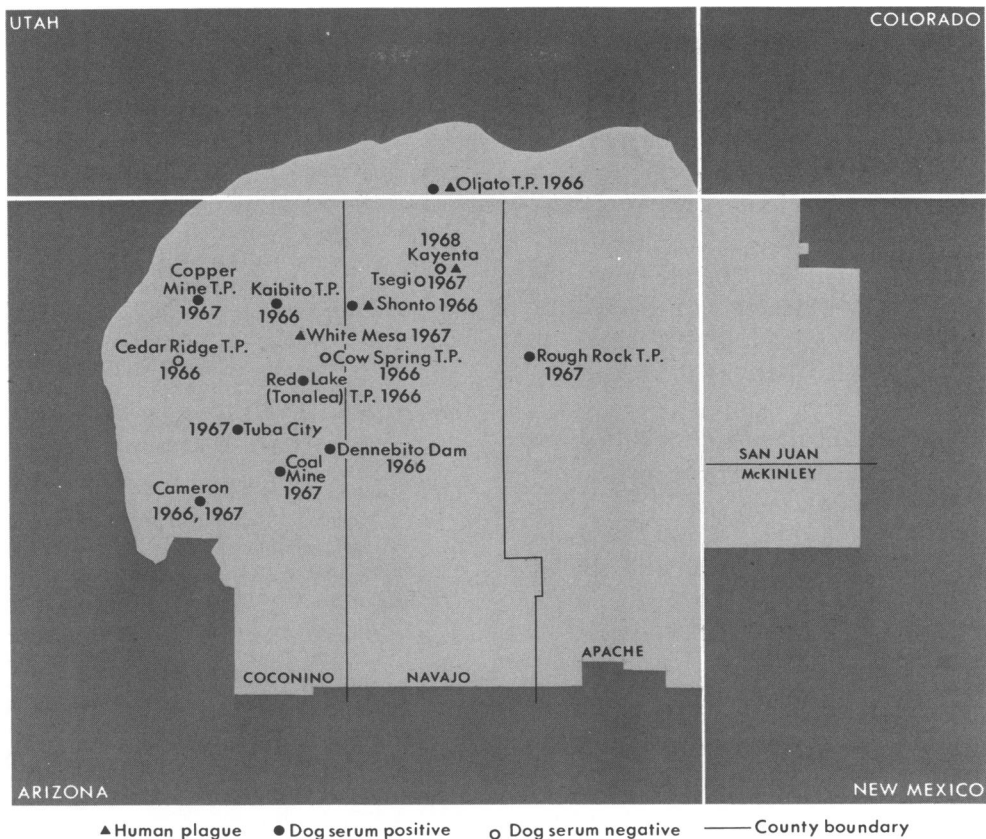
Year	Location of cases		Number of dog serums	Number of serums positive	Titer
	State	Area			
1959...	Arizona...	Houck....	3	3	1:128 1:256 1:512
1963...	New Mexico.	Albuquerque.	1	1	1:128
1965...	Arizona...	Red Rock..	6	3	1:16 1:16 1:32 1:64
	Do.....do.....	Gamerco...	9	1	1:64
	Do.....do.....	Tinian....	4	3	1:32 1:32 1:64
1966.....	do.....	Shonto-1..	30	2	1:40 1:80 1:80
	Do.....do.....	Shonto-2..	4	2	1:64 1:80
	Do... Utah....	Oljato....	3	2	1:32 1:128

¹ By passive hemagglutination test for antibodies to Fraction I of *Yersinia pestis*.

NOTES: 1965 data from reference 17, table 6, p. 1088. Shonto-1 and Shonto-2 represent two areas of possible exposure of a single case.

These nonfatal infections of dogs on the Navajo Reservation are important because of the unique place the domestic dog occupies in the life of the Navajo. Few, if any, Navajo households do not have dogs. In fact, owning dogs is an important measure of the Navajo standards of possession (8, 9), and it is not unusual for a family to have as many as 10 dogs.

Indian dogs are underfed scavengers—they are



Locations where plague activity was demonstrated by canine serum surveys, 1966–1968

free to run at will and they must forage for themselves (10, 11). Often, these dogs have been observed digging into burrows of prairie dogs that had died of plague. The families of the first six plague victims in New Mexico in 1965 had dogs “. . . which frequently brought animal carcasses into the home” (12). Actually, dogs are not allowed into Navajo dwellings, but they bring scavenged carcasses into the home area.

Navajo dogs obviously are at high risk of becoming infected, particularly during a plague epizootic among small mammals. In 1965 at Fort Wingate, N. Mex., during a plague epizootic among wild rodents, six of eight dogs sampled had positive hemagglutination antibody titers of 1:16 or 1:32 for plague. Tests for plague antibody performed by S. F. Quan, as reported by Kartman (13), on a dog from the household of a plague patient revealed an initial passive hemagglutination titer of 1: 128. Two months later the dog had a titer of 1:32 and subsequently (within a year) became seronegative.

If the antibody decline observed by Quan is consistent in other natural canine infections, then

seropositive dogs become more valuable as sentinels of recent plague activity.

It is quite possible that the association of human cases and seropositive dogs is not always coincidental. Fleas readily enter a dog’s fur, and thus they can be transported from an epizootic site to human habitats. Although Pollitzer (14) expressed the opinion that dogs are of little importance in plague transmission, he recognized the possibility of transport of infected fleas by dogs. Direct evidence of this hazard was observed at Kayenta in 1968 when *Y. pestis* was isolated from fleas (*P. irritans*) taken from the household dogs of an 8-year-old girl with bubonic plague.

Wild rodent plague, particularly that in small, inconspicuous rodents, may be present but not suspected, as happened in California, Oregon, Utah, Wyoming, and Nevada (15). Plague has been reported to traverse considerable distances without attracting attention (16). These factors indicate the need for improved means of detecting wild animal plague activity. The use of dogs as sentinels in an area too vast to be surveyed by studies of small mammals and ectoparasites should provide a logis-

tically feasible method of locating plague activity. In support of this thesis was the observance of a human case of plague at White Mesa 1 year after the initial dog survey revealed plague activity in the area (see map).

A major objective of plague investigations is to develop bases whereby potential human hazards can be defined and morbidity or mortality from human plague can be reduced. The physician who has a patient with a febrile illness, particularly with regional lymphadenitis, should suspect plague if the patient is from or has been in an area where plague is active.

On the other hand, the finding of dogs that are seropositive for plague in an area is not a final measure of the actual risk to people. The rodent reservoir relative to potential human exposure should be determined by additional field studies following the lead of seropositive dogs since effective control of plague must be at the zootic source.

REFERENCES

- (1) Meyer, K. F.: The ecology of plague. *Medicine (Balt)* 21: 143-174, May 1941.
- (2) Hudson, B. W., and Kartman, L.: The use of the passive hemagglutination test in epidemiologic investigations of sylvatic plague in the United States. *Bull Wildlife Dis Assoc* 3: 50-59, April 1967.
- (3) Mullett, C. F.: The bubonic plague in England. University of Kentucky Press, Lexington, 1956.
- (4) Fujinami, A.: Report of the international plague conference . . . Mukden, 1911. Manila, 1912.
- (5) Strong, R. C., and Teague, O.: Report of the international plague conference . . . Mukden, 1911. Manila, 1912.
- (6) Blanc, G.: Une opinion non conformiste sue le

mode de transmission de la peste. *Rev Hyg Med Soc* 4: 535-562 (1956).

- (7) Blanc, G., and Baltazard, M.: Recherches sue le mode de transmission naturelle de la peste bubonique et septicemique. *Arch Inst Pasteur Maroc* 173: 3 (1945).
- (8) Kluckhohn, C., and Leighton, D.: The Navajo. Harvard University Press, Cambridge, 1946.
- (9) Downs, J. F.: Animal husbandry in Navajo society and culture. University of California Press, Berkeley and Los Angeles, 1964.
- (10) Franciscan Fathers: An ethnologic dictionary of the Navajo language. Navajo Indian Mission, St. Michaels, Ariz., 1910, p. 536. Reprinted 1929 and 1968.
- (11) Joseph, A., Spicer, R. B., and Chesky, J.: The desert people. University of Chicago Press, Chicago, 1949.
- (12) Collins, R. N., et al.: Plague epidemic in New Mexico, 1965. Introduction and description of cases. *Public Health Rep* 82: 1077-1099, December 1967.
- (13) Kartman, L.: The role of rabbits in sylvatic plague epidemiology, with special attention to human cases in New Mexico and use of the fluorescent antibody technique for detection of *Pasteurella pestis* in field specimens. *Zoonoses Res* 1: 1-27 (1960).
- (14) Pollitzer, R.: Plague. World Health Organization, Palais Des Nations, Geneva, 1954.
- (15) Eskey, C. R., and Haas, V. H.: Plague in the western part of the United States. *Public Health Bull No. 254*. U.S. Government Printing Office, Washington, D.C., 1940.
- (16) Ecke, D. H., and Johnson, C. W.: Plague in Colorado. PHS Publication No. 210 (Public Health Monograph No. 6). U.S. Government Printing Office, Washington, D.C., 1952.
- (17) Kartman, L., et al.: Plague epidemic in New Mexico, 1965. Epidemiologic features and results of field studies. *Public Health Rep* 82: 1084-1099, December 1967.

ARCHIBALD, WILLIAM S. (Center for Disease Control), and KUNITZ, STEPHEN J.: *Detection of plague by testing serums of dogs on the Navajo Reservation. HSMHA Health Reports, Vol. 86, April 1971, pp. 377-380.*

The feasibility of locating sylvatic plague by testing the serums of domestic dogs (*Canis familiaris*) was demonstrated on the Navajo Indian Reservation in the southwestern United States. From 1959 to 1966, seropositive dogs were found in association with six cases of human plague on the reservation and one case near Albuquerque, N. Mex. In 1966 and 1967, eight areas on the Navajo

Reservation where the presence of plague activity was not known previously were shown to have active plague sites by serum surveys of dogs. In addition, plague-infected fleas (*Pulex irritans*) were removed from household dogs of a plague patient in 1968.

Periodic serum surveys for plague antibodies among domestic dogs in selected areas, such as the Navajo Indian Reservation, might

provide a helpful index of sylvatic plague activity and may be useful in ascertaining the need for control measures to prevent the occurrence of plague in man.

The use of resident dogs as sentinels of human risk was shown to be valid when a case of human plague occurred in an area where the first proof of plague activity was the finding of seropositive dogs 1 year earlier.