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Authors: Cully, Jack F., Carter, Leon G., and Gage, Kenneth L.

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New Records of Sylvatic Plague in Kansas

Jack F. Cully, Jr.,¹ Leon G. Carter,² and Kenneth L. Gage² ¹ U.S. Geological Survey, Division of Biology, Kansas State University, Cooperative Fish and Wildlife Research Unit, 204 Leasure Hall, Manhattan, Kansas 66506, USA; ² Centers for Disease Control and Prevention, National Center for Infectious Diseases, Division of Vector-Borne Infectious Diseases, P.O. Box 2087, Foothills Campus, Fort Collins, Colorado 80522, USA; Corresponding author (email: bcully@ksu.edu).

ABSTRACT: Sylvatic plague, or plague of wild rodents is caused by *Yersinia pestis* and entered California (USA) from Asia about 1899. Extensive sampling during the 1930's and 1940's documented the spread of plague to approximately its current distribution in North America. Records from the Centers for Disease Control and Prevention document plague in Kansas (USA) between 1945 and 1950, but since then there has been no documentation of plague in the state. Following a die-off of a black-tailed prairie dog (*Cynomys ludovicianus*) colony on the Cimarron National Grassland, in the southwestern corner of Kansas (37°10'N, 101°45'W), we sampled fleas from burrows in June 1997, and tested them for *Yersinia pestis*. Twelve of 13 pools of *Oropsyla hirsuta* and one of two *Pulex* sp. were positive. A similar sample of fleas, from another colony where black-tailed prairie dogs were active at the time, yielded no positive fleas.

Key words: Black-tailed prairie dogs, *Cynomys ludovicianus*, epizootic, fleas, *Yersinia pestis*.

Plague is a primarily flea-borne, zoonotic disease of wild rodents caused by the Gram negative bacillus *Yersinia pestis*. Rat-infested ships carried plague from Asia to San Francisco, (California, USA) in 1899 (Link, 1955). Plague was first encountered in wild rodents in North America in the Berkeley Hills of California in 1908 (McCoy, 1908; Wherry, 1908). During the next 50 yr, the disease spread in wild rodents throughout the western United States to approximately its current geographic distribution (Barnes, 1982, 1993). At this time plague is found in grassland, shrubland, and woodland habitats west of the 100th meridian. This boundary has been stable with minor variations for the past 50 yr (Kartman et al., 1958; Poland and Barnes, 1979; Barnes, 1993; Centers for Disease Control, 1994).

Plague is endemic in some areas, where-

as it occurs intermittently in other areas such as along the eastern border of Colorado (Barnes, 1993). Within the past 60 yr *Yersinia pestis* isolations or plague antibodies have been identified in wild mammals or fleas to the west and south of the Cimarron National Grassland, including Baca County, Colorado (1943, 1944, 1976), Cimarron and Texas counties in Oklahoma (1944, 1972), Union County, New Mexico (1943, 1944, 1949, 1989), and Dallam County, Texas (1950, 1975, 1989) (Centers for Disease Control and Prevention, unpubl. records). Black-tailed prairie dog die-offs have been observed on the Cimarron National Grassland, Kansas (Cimarron National Grassland, unpubl. records) as well as on the Comanche National Grassland to the west in Colorado (Cully, 1998). Plague also was identified in mammals and fleas in western Kansas in the 1940s and 1950s (Table 1), but has not been reported from the state since that time (Centers for Disease Control, unpubl. records). There have been no human plague cases in Kansas with the result that little plague surveillance has occurred there since 1950. It is likely that plague has been present but not recorded.

The Cimarron National Grassland (37°10'N, 101°45'W) lies within Morton and Stevens counties in extreme southwestern Kansas. It covers 43,795 ha and ranges in elevation from 960 to 1,128 m. The grassland is dissected by the Cimarron River which forms a broad valley. Upland sites north of the Cimarron River are characterized by shortgrass prairie habitat with blue gramma (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). Most of the black-tailed prairie dog colonies oc-

TABLE 1. Early plague observations from counties in western Kansas, USA.^a These records from the Centers for Disease Control document positive results for *Yersinia pestis*, but do not indicate the species of fleas involved. Date is the date of collection.

Date	County	Specimens ^b (n)	Source (rodent genus)
6/2/45	Cheyenne	105	Fleas from <i>Reithrodontomys</i> , <i>Microtus</i> , and <i>Peromyscus</i>
7/7/45	Cheyenne	73	Fleas from <i>Peromyscus</i>
7/22/45	Morton	43	Fleas from <i>Peromyscus</i>
7/24/45	Morton	53	Fleas from <i>Neotoma</i>
7/20/46	Scott	312	Fleas from <i>Cynomys</i>
8/16/46	Scott	1	Dead <i>Cynomys</i>
8/19/47	Logan	6	Fleas from <i>Onychomys</i>
8/19/47	Logan	538	Fleas from <i>Cynomys</i>
6/8/48	Scott	6	Fleas from <i>Onychomys</i>
6/8/48	Scott	57	Lice from <i>Sigmodon</i>
7/12/49	Thomas	6	Fleas from <i>Onychomys</i>
7/13/49	Thomas	341	Fleas from <i>Cynomys</i>
7/22/49	Logan	99	Fleas from <i>Cynomys</i>
7/27/49	Thomas	1	Dead <i>Cynomys</i>
7/27/49	Thomas	119	Fleas from above
8/24/50	Rawlins	128	Fleas from <i>Cynomys</i>

^a From Public Health Service Records held at the Centers for Disease Control and Prevention.

^b The number of fleas, lice, or carcasses collected.

curred in the shortgrass prairie habitat north of the Cimarron River.

In 1996, all the large (>40 ha) black-tailed prairie dog colonies on the Comanche National Grassland, Colorado, USA, 100 km to the west (Toombs, 1997), which had been active the year before, were inactive, presumably as a result of a plague epizootic spreading through these colonies (Cully, 1998). The large colonies on the Cimarron National Grassland were intact at that time.

During May 1997, the black-tailed prairie dog (*Cynomys ludovicianus*) population of a 80 ha colony on the Cimarron National Grassland abruptly declined. By June 1997, prairie dogs were no longer present at the affected colony. Fleas were collected from burrows at this colony (Colony 5) and from another 14 km west (Colony 1) where a black-tailed prairie dog was found moribund on the surface by a graduate student, but not collected, approximately 2 wk earlier. When Colony 1 was revisited in September 1998, prairie dogs were no longer active there.

Burrows were selected for flea sampling from study sites on the colonies being used

by Cully and his graduate students for another study. Fleas were sampled in black-tailed prairie dog burrows by attaching a square flannel patch, approximately 30 cm on a side, to a 4.5 m flexible steel cable. The patch was pushed as far as possible into the burrow and then slowly removed. After being removed from the burrow, the flannel patches were briefly inspected for fleas. Patches with fleas were placed in plastic bags for processing later. Burrows that allowed penetration of less than 1.5 m were not included. The maximum depth swabbed was approximately 3.5 m. Each burrow was swabbed up to five times or until two successive swabs produced no fleas. Burrows were not sampled when ambient air temperature was greater than 25 C because the fleas were too active at higher temperatures and became difficult to collect. Fleas were stored in 2% NaCl solution with a small amount of Tween-80 detergent, and refrigerated and stored for <1 wk before being sent to Centers for Disease Control (Fort Collins, Colorado, USA) for analysis.

We do not know the mode of spread of plague over long distances. It may be that

TABLE 2. Results of swabbing prairie dog burrows for fleas at the Cimarron National Grassland (Morton County, Kansas, USA) June 1997. See text for descriptions and locations of colonies.

Colony	Date	Species	<i>n</i> fleas	<i>n</i> pools	<i>n</i> positive pools
1	6/25/97	<i>Oropsylla hirsuta</i>	49	5	0
1	6/25/97	<i>Thrassis fatus</i>	2	1	0
1	6/25/97	<i>Pulex</i> sp.	1	1	0
5	6/26/97	<i>Oropsylla hirsuta</i>	178	13	12
5	6/26/97	<i>Thrassis fatus</i>	2	2	0
5	6/26/97	<i>Pulex</i> sp.	2	2	1

plague was present among other rodent species that are widespread in the short-grass prairie and more evenly distributed on the landscape than black-tailed prairie dogs. There are small isolated black-tailed prairie dog colonies between the Cimarron and Comanche National Grasslands (Cully, pers. observ.), but intervening distances are great and we believe it is unlikely that plague would have been transmitted between the grasslands by dispersing black-tailed prairie dogs. In addition to flea-borne transmission among overlapping populations and species of rodents, *Y. pestis* might be spread over considerable distances by other mammals, especially rodent-consuming carnivores that can become infested with infected rodent fleas and transport these insects from one area to another (Poland and Barnes, 1979).

In the laboratory, fleas were examined microscopically and identified to genus and species using standard taxonomic references (Hubbard, 1947; Hopkins and Rothschild, 1962; Traub et al., 1983). After identification, fleas were pooled by collection site and flea species. Flea pool size never exceeded 25 individuals. Flea pools were triturated in a small amount of physiological saline and 0.5 ml aliquots were inoculated subcutaneously into 6-wk-old Swiss Webster laboratory mice. Mice that died within 21 days underwent further bacteriological tests to confirm the presence of *Y. pestis* as described by Quan et al. (1981).

Twenty-five burrows were swabbed at colony 1 on 25 June 1997, and 20 burrows were swabbed at colony 5 on 26 June

1997. At Colony 1, 17 of 25 burrows contained fleas. Among infested burrows the mean \pm SD infestation was 4.6 ± 3.8 . At Colony 5, 18 of 20 burrows were infested and the mean \pm SD number of fleas in infested burrows was 11.1 ± 17.5 . The infestation rate was higher at Colony 5 than at Colony 1 (ANOVA $F = 3.87$, $df = 1, 43$, $P = 0.056$).

Three species of flea, *Oropsylla hirsuta*, *Thrassis fatus*, and *Pulex* sp. were collected (Table 2). *Oropsylla hirsuta* was the most common flea at both colonies. Twelve of 13 pools of *O. hirsuta* collected from Colony 5 were positive for *Y. pestis*, as was a single *Pulex* sp. Both *T. fatus* tested from Colony 5, and all fleas from Colony 1 were negative. All three species have been reported to be naturally infected with *Y. pestis*. *Oropsylla hirsuta* is a prairie dog specialist (Eskey and Haas, 1940) and is the flea most commonly encountered on black-tailed prairie dogs during the summer months. *Thrassis fatus* is a flea from the thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) that is occasionally identified in flea collections from black-tailed prairie dog colonies, particularly when black-tailed prairie dogs and thirteen-lined ground squirrels occupy the same sites. Because only female *Pulex* sp. were collected, it was impossible to determine whether the specimens were *P. irritans* or *P. simulans*. Regardless of which species was present, *Pulex* sp. are generally considered to be poor vectors of plague (Hopla, 1980). *Pulex* sp. is often associated with people, carnivores, or black-tailed

prairie dogs and other ground-dwelling sciurids in the United States.

Other factors than plague that could account for prairie dog disappearances include poisoning, shooting, flooding, and other diseases. Flooding was not a factor at the affected towns, which were well drained and not flooded during 1997. The Forest Service has not allowed poisoning black-tailed prairie dogs on the grasslands since before 1989. Shooting occurs on the grasslands, but Colonies 1 and 5 were visited regularly by J.F. Cully and his students during the period of the epizootics, and the intensive shooting that would be required to extirpate prairie dogs from the large colonies was not observed. "Plague is the only disease that causes epizootics with high mortality in prairie dogs. Tularemia is rarely found in prairie dogs" (Barnes, 1993, p. 35). Black-tailed prairie dogs serve as excellent sentinel animals for plague because they are conspicuous diurnal mammals which make it possible to detect the presence of plague by their massive die-offs. The establishment of surveillance programs to monitor plague in prairie dogs would provide useful information for wildlife managers and public health authorities.

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