Vector Control Has a Role to Play in Mitigating the High Incidence of Flea-borne Typhus in Los Angeles County, California

J. Wakoli Wekesa, **Kimberly Nelson**, **Angela Brisco**, and **Kenn Fujioka**
San Gabriel Valley Mosquito and Vector Control District, West Covina, California

ABSTRACT: More than 500 human cases of flea-borne typhus have been reported from Los Angeles and Orange Counties over the past 20 years. Only West Nile virus exceeds flea-borne typhus as an important vector-borne disease in these counties. Despite this, flea-borne typhus garners insignificant public attention compared to West Nile virus. In Los Angeles County alone there were 121 human cases of flea-borne typhus from 2000 to 2009, and 292 human cases from 2010 to 2015. Results from previous studies in Los Angeles and Orange Counties identified a suburban cycle of flea-borne typhus transmission involving backyard wildlife, pets, and the cat flea *Ctenocephalides felis*. Prior studies and recent observations in Los Angeles County showed that the flea burden of opossums and feral cats is onerously high, and the cat flea is the main vector of the pathogens (*Rickettsia typhi* and *R. felis*) responsible for human typhus. The rise of cases in recent years has been accompanied by policy changes in public and private animal control groups that manage nuisance animals in Los Angeles and Orange Counties. Instead of trapping and removing strays and supporting a policy of not feeding wild or stray animals, some governmental agencies and private organizations prefer trap, neuter, and release (TNR) programs and support rehabilitating/relocating feral animals. We believe these policy changes have contributed to the increased incidence of human typhus.

KEY WORDS: Animal control policy, cat flea, *Ctenocephalides felis*, *Didelphis virginiana*, disease, *Felis catus*, feral cats, flea-borne typhus, public health, *Rickettsia felis*, *Rickettsia typhi*, trap-neuter-return, vector-borne disease, Virginiana opossum

Proc. 27th Vertebr. Pest Conf. (R. M. Timm and R. A. Baldwin, Eds.)
Published at Univ. of Calif., Davis. 2016. Pp. 288-292.

INTRODUCTION

Flea-borne typhus is a zoonotic disease prevalent in tropical and subtropical parts of the world including Africa, Southeast Asia, and the Mediterranean (Dumler et al. 1987, Azad 1990, Jiang et al. 2013) and is becoming increasingly common in parts of the United States (Civen and Ngo 2008, Eremeeva et al. 2012). In the early 1900s, cases of flea-borne typhus were widespread and very common in the United States; however, for reasons not well-explained the number of cases declined over many decades. By the mid-1900s, cases of flea-borne typhus declined to relatively few (Woodward 1973, Azad et al. 1997) and in 1994 the Centers for Disease Control and Prevention (CDC) delisted it as a reportable disease (Beck and Van Allen 1947, Adams et al. 1970, CDC 1982). However, in the late 1990s, the number of cases started to increase again. This increase was most significant in three states where flea-borne typhus is currently endemic; California, Hawai'i, and Texas (Taylor et al. 1986, Dumler et al. 1987, Reporter et al. 1996). The disease is not widespread throughout these states but confined to specific regions, especially in California. Flea-borne typhus is most common in Los Angeles and Orange Counties (Williams et al. 1992, Sorvillo et al. 1993). In Hawai'i, it is common in Maui County (Eremeeva et al. 2008), and in Texas it is common in Cameron, Hidalgo, Nueces, and Travis Counties (Taylor et al. 1986, Dumler et al. 1987, Boostrom et al. 2002). The reasons for these distributions are not well known and difficult to determine–without a better understanding of the ecology of typhus in relationship to reservoir species – opossums (*Didelphis virginiana*) and feral cats (*Felis catus*) – which often are overabundant (Reporter et al. 1996, Gerhold and Jessup 2013).

In this article, we argue that flea-borne typhus is a major public health threat for residents of Los Angeles and Orange Counties, and over the past 20-30 years its transmission is more closely associated with opossums, cats, and its vector, the cat flea (*Ctenocephalides felis*) (Sorvillo et al. 1993, Eremeeva et al. 2012). The historical spread of typhus has been attributed by others to an increased abundance of outdoor cats, and to the practice of outdoor feeding of feral cats, which attracts urban wildlife that includes opossums, skunks (*Mephitis mephitis*), and raccoons (*Procyon lotor*) (Reporter et al. 1996, Civen and Ngo 2008). The presence of wildlife may increase the abundance of fleas, which may contribute to additional cases of flea-borne typhus (Gerhold and Jessup 2013, Nelson et al. 2016). Public health agencies, especially those charged with animal control (public agencies or private), must understand that vector control districts have a major responsibility in controlling this disease.

The Life Cycle of Flea-Borne Typhus

Flea-borne typhus is caused by *Rickettsia typhi* (the causative agent of murine typhus) and *R. felis* (Dyer 1944, Williams et al. 1992, Sorvillo et al. 1993, Azad et al. 1997). Two recently identified *Rickettsia* (*R. asemboensis* and *R. senegalensis*) may be involved in flea-borne typhus but their role is undefined (Karpathy et al. 2009, Jiang et al. 2013, Billeter et al. 2016, Maina et al. 2016). Transmission of flea-borne typhus occurs in two known life cycles: the classic cycle and the suburban cycle. The classic cycle (also referred to as the traditional cycle) involves *R. typhi* maintained in commensal rats such as *Rattus norvegicus* and *R. rattus*, and transmitted to humans by a bite of an infected Oriental rat flea (*Xenopyslla cheopis*), or by contamination of broken skin with feces of infected *X. cheopis* (Azad et al. 1997). The recently-described suburban life cycle involves *R. felis* maintained in opossums, commensal rats, and cats by *C. felis* (Sorvillo et al. 1993, Gerhold

and Jessup 2013). The cat flea (*C. felis*) may be infected by *R. felis* after feeding on an infected vertebrate host (opossum, rat, or domestic cat) or by vertical transmission where infected female fleas transmit *R. felis* to young (Wedincamp and Foil 2002). Vertical transmission is consequential in areas where large populations of urban wildlife (e.g., opossums, skunks, and raccoons), feral cats, and dogs (*Canis familiaris*) are present. An abundance of vertebrate hosts in a neighborhood provides blood sources for *C. felis*, which may increase their population and the risk of flea-borne typhus (Wedincamp and Foil 2002, Gerhold and Jessup 2013).

Currently, clinical diagnosis of human infections with *R. typhi* is done by serology and direct and indirect immunofluorescent assay (IFA). Although the purpose of these clinical tests is to identify *R. typhi*, infections with *R. felis* and other *Rickettsia* species are included because IFA cross-reacts to *R. felis* (Civen and Ngo 2008). In recent years, *R. felis* and other *Rickettsia* species have been detected with increasing frequency in molecular analysis of *C. felis* collected from opossums, cats, and other animals (Henry et al. 2007, Nogueras et al. 2013). Recently, *R. felis* has been found more commonly than *R. typhi* and other *Rickettsia spp.* from peripheral blood of cats and opossums. In southern California, especially in Los Angeles and Orange Counties, *R. felis* is the most prevalent pathogen, with transmission primarily associated with the suburban life cycle (Sorvillo et al. 1993, Karpathy et al. 2009, Eremeeva et al. 2012). In nearby San Bernardino County, *R. felis* was present in cat fleas collected off opossums without recently documented reports of human flea-borne typhus (Abramowicz et al. 2012). Furthermore, there may be other *Rickettsia* spp. involved in the dynamics of this disease; Billeter et al. (2016) suggest this, as *R. felis* occurs equally in *C. felis* collected from cats where cases of flea-borne typhus are both present and absent.

The Ecology of Flea-Borne Typhus in Southern California

Thousands of cases of flea-borne typhus were described annually in the United States before *R. typhi* was identified as the causative agent of murine typhus (Beck and Van Allen 1943, Dyer 1944). These cases were always associated with commensal rats and their fleas; whenever they were present in high numbers, cases of typhus were common. The incidence remained high until the late 1940s (Beck and Van Allen 1943, Halverson 1942). The impact of plague surveillance and control from the 1950s through mid-1980s, and many environmental changes championed by federal, state, local public health agencies, and private organizations (e.g., the Rockefeller Foundation) may have greatly contributed to reducing the incidence of flea-borne typhus (Woodward 1973, Schwan et al. 1985, Nelson et al. 1986, Wekesa et al. 2016). The discovery of *R. felis* in the 1990s coincided with an upsurge of flea-borne typhus in Los Angeles and Orange Counties (Sorvillo et al. 1993). In Los Angeles County, cases were previously zero or near zero but increased to about ten cases per year in the mid-1990s (Reporter et al. 1996). In 2010, there were about 50 cases, and by 2013 the average had increased to over 100 annually (LACDPH 2013, CDPH 2014). Some of the cases in Los Angeles County have been in clusters within specific neighborhoods. Wekesa *et al.* (2016) reviewed cases that occurred over the past two decades and found several clusters of illness including the outbreak that occurred among Pasadena residents in 2005, a cluster in Long Beach in 2009, and a cluster in Pomona in 2015. The common thread in these outbreaks is opossums infested with *C. felis* in neighborhoods with a high abundance of feral cats, and colonies of feral cats living close to humans.

Managing and controlling cases and future outbreaks of flea-borne typhus must include controlling outdoor cats and associated wildlife (Gerhold and Jessup 2013, Nelson et al. 2016). The 1998 Hayden Act protects animals in shelters and increased the holding time of impounded animals from 72 hours to six days before being euthanized (SB1785 1998). This law intended to reduce euthanasia of unclaimed animals. In addition, the law had "no kill" provisions, which when implemented by local governments, created policies for sterilizing feral animals including trap-neuter-return (TNR), rehabilitation, and relocation (Gerhold and Jessup 2013, Cummings et al. 2014). The unforeseen consequence of its passage was the increase of number of cats and dogs released into communities without food and shelter. The major component of this law that caused an explosion of feral animals (cats and dogs) was a provision making it easier for animal adoption and rescue organizations to request the release of unclaimed animals into their care, which they in turn released into neighborhoods, forming large populations of free-roaming cats and dogs (Longcore et al. 2009). Feeding these feral animals attracted urban wildlife such as opossums, skunks, and raccoons, creating an environment conducive to producing a high population of *C. felis* which sustained flea-borne typhus transmission (Gerhold and Jessup 2013). Such areas may also attract additional wildlife such as coyotes (*C. latrans*) and bobcats (*Lynx rufus*), which will feed on feral cats and other small mammals in these colonies/herds (Rutledge et al. 1979, Schwann et al. 1985). Infected fleas on these preys potentially will seek other hosts, further worsening the typhus situation.

Mosquito Abatement and Vector Control Law

The legal authority to control flea-borne typhus and other vector-borne diseases is found in the California State Health and Safety Code (Chapter 1, Division 3, Sections 2200-2093) originally enacted in 1915, revised in 1939 and 1980, and re-written in 2002. The law is popularly known as the "Mosquito Abatement and Vector Control District Law." It guides vector control districts on how to manage and control vectors and vector-borne diseases within their jurisdictions. The districts under direction of their governing bodies can conduct surveillance, prevention, abatement, and control of fleas and their vertebrate hosts (SB-1588, 2002).

The law defines a vector as "any insect or other arthropod, rodent or other animal of public health significance capable of harboring or transmitting the causative agents of human disease, or capable of causing human discomfort and injury." The mosquito abatement law defines control as an act of preventing or reducing vector population. The law further defines "abate" as a process of putting an end to or reducing the intensity of a public nuisance. In the

context of flea-borne typhus, any property artificially altered from its natural condition (i.e., any developed property) that supports the development, attraction, or harborage of vectors may be declared a public nuisance and abated. Any developed property, public or privately owned onto which opossums and feral cats congregate in large numbers with their fleas can be declared a public nuisance and abated. This approach is the most effective method of reducing the risk of flea-borne typhus, not necessarily focusing solely on *C. felis* but on all conditions in a given area creating the risk (Croker et al. 2016, Nelson et al. 2016, Wekesa et al. 2016).

A meaningful effort to control or manage flea-borne typhus must involve all public health agencies including environmental health, animal control, veterinary services, divisions that perform communicable disease control, and vector control. The mosquito and vector control law mandates that districts pursue vectors responsible for transmitting diseases or causing a public nuisance within and beyond their boundaries. In this scenario, vector control agencies must focus on reducing the public health risk by eliminating the conditions which create the risk. This must include removing the underlying conditions for an outbreak, such as presence of outdoor cats and opossum, until the potential for disease is mitigated. Vector control must cooperate with other agencies to achieve this goal and utilize the provisions within the mosquito abatement and vector control law to bring the intensity of an outbreak under control.

Feeding feral cats or maintaining a colony of them in any given location or neighborhood supports *C. felis*, which is a known vector of typhus. These sites can be declared public nuisance and abated by vector control agencies. This action once brought may require involvement of all stakeholders to reduce the intensity of a public nuisance. Such action was recently brought by the San Gabriel Valley Mosquito and Vector Control District to control cat fleas, opossums, and feral cats while responding to an outbreak of 5 human cases that occurred in 2015 in the City of Pomona. The cooperation of the Los Angeles County Department of Public Health (LACDPH), State Housing and Community Development, the office of the local state senator, the City of Pomona, and the San Gabriel Valley Mosquito and Vector Control District were instrumental in reducing the intensity of the outbreak and mitigating it to a level where no additional cases have occurred for the past 12 months (Croker et al. 2016, Nelson et al. 2016).

The District's Flea-Borne Typhus Surveillance and Control Program

The San Gabriel Valley Mosquito and Vector Control District (hereafter, "District") has established a surveillance and control program for fleas that may transmit flea-borne typhus. The program works in cooperation with the Los Angeles County Department of Public Health's Environmental Health disease investigators. In 2014, the District added this program onto its surveillance programs and realigned its staff to provide enhanced surveillance and control for flea-borne typhus. The work focuses on service requests from residents with potential flea complaints and those from neighborhoods with feral cats and opossums. The program also conducts follow-up investigation of suspect, probable, and confirmed typhus cases referred from the LACDPH. All activities are focused on reducing flea burdens in the communities and reducing conditions that may increase the risk of disease in neighborhoods. In addition to surveillance and control, the program also conducts abatement actions to mitigate potential disease outbreaks (Nelson et al. 2016, Wekesa et al. 2016).

The District's program complements the overall effort of responding to flea-borne typhus by LACDPH. The county program conducts outreach and public education, and we enhance these efforts but do not supplant them (LACDPH 2013). The District's program advises property owners and city residents about changes that can be made so a property is less conducive to harboring *C. felis*, feral cats, and opossums.

CONCLUSION

Since controlling flea-borne typhus is a priority in Los Angeles County and important to public health we are mandated to intervene, actively participate, and reduce potential for disease outbreaks, and/or act to reduce the intensity of an ongoing outbreak. To achieve these goals, the District must have an ongoing program to control and manage this and other similarly vectored diseases. Furthermore, our work calls for the involvement of all public and private stakeholders who are committed to reducing the potential for flea-borne typhus transmission.

Vector control agencies must not "cede" their responsibility of protecting residents, especially when conditions creating the public health risk of typhus involve pets and animals normally not under their care but under the purview of animal control and veterinary agencies. These matters are controversial and touch on emotions, but we must educate all stakeholders about the consequences of inaction or wrong actions and to properly care for animals. We must also encourage them to follow science, especially when it appears counterintuitive to managing our companion animals which are domestic, not wild.

LITERATURE CITED

Abramovicz, K. F., J. W. Wekesa, C. N. Nwadike, M. L. Zambrano, S. E. Karpathy, D. Cecil, J. Burns, R. Hu, and M. E. Eremeeva. 2012. *Rickettsia felis* in cat fleas, *Ctenocephalides felis* parasitizing opossums, San Bernardino County, California. Med. Vet. Entomol. 26:458-462.

Adams, W., R. Emerson, and J. Brooks. 1970. The changing ecology of murine (endemic) typhus in Southern California. Am. J. Trop. Med. Hyg. 19:311-318.

Azad, A. F. 1990. Epidemiology of murine typhus. Ann. Rev. Entomol. 35:553-569.

Azad, A. F., S. Radulovic, J. A. Higgins, B. H. Noden, and J. M. Troyer. 1997. Flea-borne rickettsioses: ecologic considerations. Emerg. Infect. Dis. 3:319-327.

Beck, M. D., and A. Van Allen. 1947. Typhus fever in California, 1916-1945, inclusive: an epidemiologic and field laboratory study. Am. J. Hyg. 45:335-354.

Billeter, S. A., P. P. V. de Paiva Diniz, L. A. Jett, A. L. Wournell, A. M. Kjemtrup, K. A. Padgett, M. H. Yoshimizu, M. E. Metzger, and M. C. Barr. 2016. Detection of Rickettsia species in fleas collected from cats in regions endemic and non-endemic for flea-borne rickettsioses in California. Vector-Borne Zoon. Dis. doi: 10.1089/vbz.2015.1869.

Boostrom, A., M. S. Beier, J. A. Macaluso, R. Macaluso, D. Sprenger, J. Hayes, S. Radulovic, and A. F. Azad. 2002. Geographic association of *Rickettsia felis*-infected opossums with human murine typhus, Texas. Emerg. Infect. Dis. 8: 549-554.

CDC. 1982. Urban rat control program – United States. Centers for Disease Control and Prevention. MMWR Morbidity and Mortality Weekly Reports, 31:259-260.

CDPH (California Department of Public Health). 2014. Flea-borne typhus. Website, California Dept. of Public Health, Sacramento, CA. http://www.cdph.ca.gov/HealthInfo /discond/Documents/Flea-borneTyphus.pdf

Civen, R., and V. Ngo. 2008. Murine typhus: an unrecognized suburban vector-borne disease. Clin. Infect. Dis. 46:913-918.

Croker, C., C. Foo, M. Tormey, K. Nelson, J. W. Wekesa, K. K. Fujioka, R. Civen, and L. Mascola. 2016. Opossums, fleas and human disease: a collaborative approach for mitigating an outbreak of murine typhus in a mobile home community, Los Angeles County, California, 2015. The 2016 Annual Conference of the Council of State and Territorial Epidemiologists, June 19-23, 2016, Anchorage, AK.

Cummings, R., L. Krueger, K. Nguyen, C. Fogarty, S. Bennett, R. Velten, M. Hearst. 2014. The conflicting roles of vector control and animal control agencies in mitigating the rise of human cases of flea-borne typhus in Orange County, California. Proc. Vertebr. Pest Conf. 26:316-322.

Dumler, J. S., J. P. Taylor, and C. H. Walker. 1987. Clinical and laboratory features of murine typhus in south Texas, 1980 through 1987. J. Am. Med. Assoc. 266:1365-1370.

Dyer, R. E. 1944. The rickettsial diseases. J. Am. Med. Assoc. 124:1165-1167.

Eremeeva, M. E., W. R. Warachina, M. M. Sturgeon, A. E. Buchholz, G. K. Olmsted, S. Y. Park, P. V. Effler, and S. E. Karpathy. 2008. *Rickettsia typhi* and *R. felis* in rat fleas (*Xenopyslla cheopis*), Oahu, Hawaii. Emerg. Infect. Dis. 14:1613-1615.

Eremeeva, M. E., S. E. Karpathy, L. Krueger, E. K. Hayes, A. M. Williams, Y. Zaldivar, S. Bennett, R. Cummings, A. Tilzer, R. K. Velten, N. Kerr, G. A. Dasch, and R. Hu. 2012. Two pathogens and one disease: detection and identification of flea-borne Rickettsiae in areas endemic for murine typhus in California. J. Med. Entomol. 49:1485-1494.

Gerhold, R. W., and D. A. Jessup. 2013. Zoonotic diseases associated with free-roaming cats. Zoon. Publ. Health 60(3): 189-195.

Halverson, W. L. 1942. Typhus fever in California. Cal. West. Med. 57(3):196-200.

Henry, K. M., J. Jiang, P. J. Rozmajzl, A. F. Azad, K. R. Macaluso, and A. Richards. 2007. Development of quantitative real-time PCR assays to detect *Rickettsia typhi* and *Rickettsia felis*, the causative agents of murine typhus and flea-borne spotted fever. Mol. Cell Probes 21:17-23.

Jiang J., A. N. Maina, D. L. Knobel, S. Cleaveland, A. Laudisoit, K. Wamburu, E. Ogola, P. Parola, R. F. Breiman, M. K. Njenga, and A. L. Richards. 2013. Molecular detection of *Rickettsia felis* and *candidatus* Rickettsia asemboensis in fleas from human habitats, Asembo, Kenya. Vector Borne Zool. Dis. 11:550-558.

Karpathy, S. E., E. K. Hayes, A. M. Williams, R. Hu, L. Kruger, S. Bennett, A. Tilzer, R. K. Velten, N. Kerr, W. Moore, and M. E. Eremeeva. 2009. Detection of *Rickettsia felis* and *Rickettsia typhi* in an area of California endemic to murine typhus. Clin. Microbio. Infect. 15 (Suppl. 2): 218-219.

LACDPH (Los Angeles County Department of Public Health). 2013. Typhus fever. Pp. 201-206 *in*: 2013 Annual Morbidity Report. Acute Communicable Disease Control Program, Los Angeles County Dept. of Public Health, Los Angeles, CA. http://publichealth.lacounty.gov/acd/reports/annual/2013Annual.pdf

Longcore, T., C. Rich, and L. M. Sullivan. 2009. Critical assessment of claims regarding management of feral cats by trap-neuter-return. Conserv. Biol. 23:887-894.

Maina, A. N., C. Fogarty, L. Kruger, K. R. Macaluso, A. Odhiambo, K. Nguyen, C. M. Farris, A. Luce-Fedrow, S. Bennett, J. Jiang, S. Sun, R. F. Cummings, and A. L. Richards. 2016. Rickettsial infections among *Ctenophalides felis* and host animals during a flea-borne rickettsioses outbreak in Orange County, California. PLOS ONE, 11(8), DOI:10.1371/journal.pone.0160604.

Nelson, K. J., M. A. Brisco, G. Holguin, C. Foo, C. Crooker, M. Cook, R. Civen, K. K. Fujioka, and J. W. Wekesa. 2016. Use of Abatement to Reduce Intensity of a Flea-Borne Typhus Outbreak in the San Gabriel Valley, Los Angeles County, California. Proc. Mosq. Vector Control Assoc. Calif. 84:104-106.

Nelson, B. C., M. B. Madon, and A. Tilzer. 1986. The complexities at the interface among domestic/wild rodents, fleas, pets, and main in urban plague ecology in Los Angeles, County, California. Proc. Vertebr. Pest Conf. 12:88-96.

Nogueras, M. M., I. Pons, A. Artuno, J. Miret, J. Pia, J. Castella, and F. Segura. 2013. Molecular detection of *Rickettsia typhis* in cats and fleas. PLos ONE. 8(8):e71386. doi: 10.1371/journal.pone.0071386.

Reporter, R., D. E. Dassey, L. Mascola. 1996. Murine typhus still exists in the United States. Clin. Infect. Dis. 23:205.

Rutledge, L. C., M. A. Moussa, B. L. Zeller, and M. Lawson. 1979. Field studies of reservoirs and vectors of sylvatic plague at Fort Hunter Liggett, California. J. Med. Entomol. 15:452-458.

SB-1588. 2002. Mosquito abatement: pest abatement: vector control districts. Senate Bill 1588, State of California. California Legislative Information. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200120020SB1588

SB-1785. 1998. Hayden Law. Senate Bill 1785, State of California. California Legislative Information. http://www.leginfo.ca.gov/pub/97-98/bill/sen/sb_1751-1800/sb_1785_bill_19980923_chaptered.html

Schwan T. G., D. Thompson, B. C. Nelson. 1985. Fleas on roof rats in six areas of Los Angeles County, California: their potential role in the transmission of plague and murine typhus to humans. Am. J. Trop. Med. Hyg. 34:372-379.

Sorvillo, F. J., B. Gondo, R. Emmons, P. Ryan, S. H. Waterman, A. Tilzer, E. M. Andersen, R. A. Murray, and R. Barr. 1993. A suburban focus of endemic typhus in Los Angeles County: association with seropositive domestic cats and opossums. Am. J. Trop. Med. Hyg. 48:269-273.

Taylor, J. P., T. G. Betz, and J. A. Rawlings. 1986. Epidemiology of murine typhus in Texas, 1980 through 1984. J. Am. Med. Assoc. 255: 2173-2176.

Wedincamp, J. Jr., and L. D. Foil. 2002. Vertical transmission of *Rickettsia felis* in the cat flea (*Ctenocephalides felis* Bouche). J. Vector Ecol. 27(1):96-101.

Wekesa, J. W., K. Nelson, A. Brisco, and K. Fujioka. 2016. History of flea-borne typhus in Los Angeles County, California. Proc. Mosq. Vector Control Assoc. Calif. 84:1-6.
Williams, S. G., J. B. Sacci, Jr., M. E. Schriefer, E. M. Andersen, K. K. Fujioka, F. J. Sorvillo, A. R. Barr, and A. F. Azad. 1992. Typhus and typhus-like *Rickettsia* associated with opossums and their fleas in Los Angeles County, California. J. Clin. Microbiol. 30:1758-1762.
Woodward, T. E. 1973. A historical account of the rickettsial diseases with a discussion of unsolved problems. J. Infect. Dis. 127:583-594.