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SHORT COMMUNICATIONS

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Antibodies to *Borrelia* sp. in Wild Foxes and Coyotes from Wisconsin and Minnesota

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ABSTRACT: Serum samples from 93 red foxes (*Vulpes vulpes*) and nine gray foxes (*Urocyon cinereoargenteus*) trapped in Wisconsin and 23 coyotes (*Canis latrans*) trapped in Wisconsin and Minnesota were tested for antibodies to *Borrelia* sp. with an indirect fluorescent antibody test which used *Borrelia burgdorferi* as the whole-cell antigen. Seven red foxes (8%) and two coyotes (9%) had antibody titers ≥1:64. All the positive samples were from areas known to be endemic for human Lyme disease. Implications for the epizootiology of Lyme borreliosis in wild canids are not well understood, but even if these species are not actual reservoirs of *B. burgdorferi* they could serve to increase the range of the vector and establish new endemic foci of the spirochete.

Key words: *Borrelia* sp., coyote, red fox, gray fox, *Canis latrans*, *Vulpes vulpes*, *Urocyon cinereoargenteus*, serologic survey, Lyme disease.

Borrelia burgdorferi, the etiologic agent of Lyme disease in humans, is endemic in much of Wisconsin and Minnesota. Incidence of the disease in the upper midwestern USA is increasing, probably as a result of the expanding range of the primary vector *Ixodes dammini* (Davis et al., 1984; Osterholm et al., 1984; Godsey et al., 1987).

Borrelia burgdorferi has been shown to infect many species of wild and domestic animals. Of particular interest to this report is the susceptibility of certain Canidae, both wild and domestic (Kornblatt et al., 1985; Kazmierczak et al., 1988). Movement of domestic dogs and seasonal dispersal of wild canids have been postulated as means of spread of *I. dammini* into nonendemic areas (Godsey et al., 1987). However, the prevalence of *B. burgdorferi* infection in abundant free-living canids like foxes and coyotes was not known. To this end, a survey was performed to obtain serologic evidence of *B. burgdorferi* infection in wild red foxes (*Vulpes vulpes*), gray foxes (*Urocyon cinereoargenteus*) and coyotes (*Canis latrans*) in Wisconsin and Minnesota.

Fox sera were obtained from the Wisconsin Department of Natural Resources (Madison, Wisconsin 53707, USA). These consisted of 93 red fox and nine gray fox samples from animals trapped in the autumn of 1984 in various parts of Wisconsin (USA). Trapping and serum collection were performed by private trappers in 19 counties (Fig. 1). Coyote sera were provided by the Departments of Natural Resources in Minnesota (St. Paul, Minnesota 55155, USA) and Wisconsin. Twenty-three coyote samples from animals trapped from 1979 through 1985 were tested. Of these, 19 were from Minnesota, obtained in the counties of Itasca (n = 16) (47°05′ to 47°40′N, 93°05′ to 93°40′W) and Aitken (n = 3) (46°48′N, 93°30′W). The four Wisconsin samples were obtained in the counties of Douglas (n = 3) (46°24′N, 92°06′W) and Dane (n = 1) (43°04′N, 89°23′W).

Antibody titers to *Borrelia* sp. in both the fox and coyote samples were determined by means of an indirect fluorescent antibody (IFA) test, using a method previously described (Steere et al., 1983). The whole-cell antigen used was the seventh culture passage of an isolate of *B. burgdorferi* cultured from a white-footed mouse (*Peromyscus leucopus*) from Wisconsin. The antiserum used was fluorescein isothiocyanate-conjugated goat anti-dog

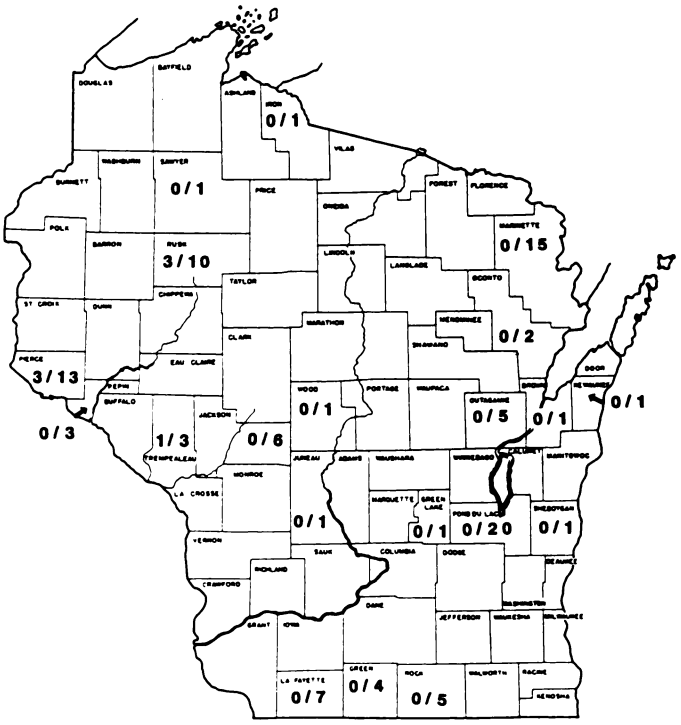

FIGURE 1. Source of fox sera from counties in Wisconsin (USA). Numerator represents the number of foxes with an antibody titer to *Borrelia* sp. ≥1:64; denominator represents total number of foxes tested in that county.

IgG (Cappell Worthington Laboratories, Malvern, Pennsylvania 19355, USA) at a dilution of 1:40. Known *B. burgdorferi*-positive and -negative dog sera served as controls for each test. Sera were initially screened at a dilution of 1:8. Samples reactive at this dilution were tested at two-fold serial dilutions until an endpoint titer was determined. The antibody titer was defined to be the highest serum dilution at which definite fluorescence was observed.

Of the 93 red fox samples tested, seven were reactive in the IFA test at levels ≥1:64 (8%). These samples included three from Pierce County (titers of 1:64, 1:256, and 1:512); three from Rusk County (titers of 1:64, 1:64, and 1:256); and one from Trempealeau County (titer of 1:128) (Fig. 1). None of the grey fox sera showed significant levels of reactivity.

Two of 23 coyote samples had antibody titers of ≥1:64 (9%), including one animal trapped in Itasca County, Minnesota in 1980 which had a titer of 1:64 and another trapped in Douglas County, Wisconsin in 1985 whose titer was 1:1,024.

An antibody titer of ≥1:64 has been considered evidence of prior *B. burgdorferi* infection in dogs (Magnarelli et al., 1985; Burgess, 1986a). While the Lyme disease spirochete has some antigenic relatedness with the *Leptospira interogans*, the degree of cross-reactivity is minor (Magnarelli et al., 1985, 1986). Of greater concern in serologic surveys of wildlife is the considerable cross-reactivity between *B. burgdorferi* and some other members of the genus, notably the tick-borne relapsing fever spirochete *Borrelia hermsii*, and *Borrelia coriaceae*, the postulated agent of epizootic bovine abortion (Magnarelli et al., 1986; Lane and Burgdorfer, 1988). These two species of *Borrelia* in North America, however, are limited to the western United States and Canada (Barbour and Hayes,

1986). Even so, we cannot rule out the possibility that infection with some other *Borrelia* sp. was responsible for the reactivity seen in our IFA tests. However, the fact that significant antibody titers in our study were found only in areas where human Lyme disease is endemic (Davis et al., 1984; Osterholm et al., 1984) suggests that the antibodies were indeed produced as a result of infection with *B. burgdorferi*. Within the known Lyme-endemic areas of Wisconsin as described by Davis et al. (1984), seven of 39 fox samples (18%) were reactive at levels ≥1:64, while none of 63 fox samples obtained from outside the endemic area had significant antibody levels.

The effects of *B. burgdorferi* infections in wild Canidae are not yet known. In the domestic dog, infection can result in fever, lymphadenopathy, arthralgia and arthritis (Kornblatt et al., 1985). An experimentally infected gray wolf (*Canis lupus*) developed a lymphadenopathy, suggesting that the spirochete is pathogenic for this species (Kazmierczak et al., 1988).

Another area which requires further investigation is the reservoir competence of Canidae. There are numerous reports of foxes and coyotes being parasitized by known or suspected vectors of *B. burgdorferi*, including *I. dammini* (Spielman et al., 1979), *Ixodes scapularis* (Cooley and Kohls, 1945; Bloemer and Zimmerman, 1988), *Amblyomma americanum*, and *Dermacentor variabilis* (Sonenshine and Stout, 1971; Bloemer and Zimmerman, 1988). However, it is not known whether canids can develop a spirochetemia of sufficient magnitude to infect tick vectors. The fact that experimentally infected domestic dogs can infect other dogs by contact transmission of the spirochete (Burgess, 1986b) suggests that at least this species of canid could be a direct source of infection for other animals under natural conditions.

Even if they are not actual reservoirs of *B. burgdorferi*, species such as red foxes and coyotes that are widely distributed, abundant, and highly mobile could serve to both increase the geographical range of vectors like *I. dammini* and to establish new endemic foci of the Lyme disease spirochete. Studies from Minnesota and Wisconsin cite juvenile dispersal distances up to 80 and 86 km for coyotes and red foxes, respectively (Berg and Chesness, 1978; Pils and Martin, 1978). In addition, these canids are often in close proximity to human habitation. The average distance of fox dens to farmsteads in Wisconsin was found to be 0.5 km (Pils and Martin, 1978). Coyotes are known to frequently travel long distances to associate with livestock (Danner and Smith, 1980). Such factors could easily bring humans and domestic animals in contact with coyote- and fox-borne ectoparasites.

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