Tick (Acari: Ixodidae) vectors of Lyme Disease organisms (*Borrelia burgdorferi*) in Florida[1]

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INTRODUCTION: Lyme disease, a newly recognized arthropod-borne zoonosis, is rapidly becoming an important public health problem in many areas of the United States. This spirochete-initiated disease is vectored and maintained by a hard tick, *Ixodes dammini* Spielman, Clifford, Piesman, & Corwin, in northeastern North America and by other species of ticks in other areas.

The initial identification of the disease started in 1975, when Dr. Allen Steere, a Yale rheumatologist, was studying an unexplained high frequency of arthritis in 3 small adjoining communities in Connecticut: Old Lyme, Lyme, and East Hadden. About 25 percent of the patients recalled having a skin rash. Some patients recalled being bitten by a tick. Dr. Steere described this new disease as Lyme disease (Benzaia, 1989).

In 1982, Dr. Burgdorfer discovered the responsible infectious agent, a spirochete, *Borrelia burgdorferi* Johnson, Schmidt, Hyde, Steigerwalt, and Brenner, in *Ixodes* ticks associated with deer and mice (Burgdorfer, 1984). The first association of *Ixodes* ticks and Lyme disease-like symptoms was reported in 1910 by Dr. Arvid Afzelius, a Swedish dermatologist, who reported a similar rash following tick bites by *Ixodes ricinus* (Linnaeus) (Benzaia, 1989).

DISTRIBUTION OF THE DISEASE: Lyme disease is now distributed in Europe, Asia, Australia, Japan, China, U.S.S.R., and North America. In western North America it has been recorded from British Columbia in Canada, and in the states of Idaho, Nevada, Oregon, Utah, California (coastal counties north of San Francisco), and Washington (Benzaia, 1989). The distribution in the United States appears to be expanding both geographically and with reference to potential vectors. It is found in the north central states and along the east coast including Florida with a total of 43 states in 1989.

In Florida, recent cases of Lyme disease have been verified by the Communicable Disease Center (CDC), Ft. Collins, which now recognizes it as endemic in 4 Florida counties including Hillsborough, Orange, Santa Rosa, and Volusia. Twenty-seven counties in neighboring Georgia, and 5 Alabama counties were also identified as having native cases. Epidemiology associated with at least one of these cases identified the disease as present in the north-central Florida county of Alachua and indicates that this area should be added to the list of endemic areas in the state (Raad et al., in press).

The tick species which experimentally transmit the disease or in which the microorganism was recovered from field-collected ticks implies that these species may become very important in maintaining the endemic state in reservoir animals for these areas. The listed potential vectors of *B. burgdorferi* include: *Amblyomma americanum* (Linnaeus), *Dermacentor variabilis* (Say), and *Ixodes scapularis* Say (Piesman, 1988; Piesman & Sinsky, 1988; Magnarelli & Anderson, 1988); *Ixodes pacificus* Cooley & Kohls (Lane & Burgdorfer, 1978; Burgdorfer et al., 1985a; Bissett & Hill, 1987); *Dermacentor albipictus* Packard (Magnarelli et al., 1986). *Ixodes scapularis* has been shown to be competent vector by Burgdorfer & Gage (1987), while Schulze et al. (1986), further incriminated *I. dammini* and *A. americanum*. *Ixodes dentatus* Marx has been incriminated as the vector of *B. burgdorferi* in a rabbit-borrelia-tick cycle in Massachusetts (Telford & Speilman, 1990, in press) and New York (Anderson et al., 1989). Another common tick, *Amblyomma maculatum*, should be considered in the south eastern states as a potential vector because it has demonstrated efficiency in transmitting several types of disease organisms (Christian, 1989). Oliver & Owsley (1988) have reported that *I. dammini* and *I. scapularis* cannot be separated genetically on the basis of chromosomes and hybridization tests, while *I. pacificus* appears to be distinct from them.

While it is probably of lesser epidemiological significance, Magnarelli et al. (1988a) reported evidence of *B. burgdorferi* spirochetes in 6 species of deer flies and horse flies (Tabanidae) and 3 species of *Aedes* mosquitoes and suggested that the presence of *B. burgdorferi* in these insects in endemic areas increases the risk of Lyme disease spread. Magnarelli et al. (1988b) demonstrated antibodies against *B. burgdorferi* in susceptible laboratory hamsters which were exposed to field-collected *Aedes canadensis* and *A. stimulans*. The majority of the listed tick species as well as the tabanids and mosquitoes is present in Florida for extended seasonal periods.
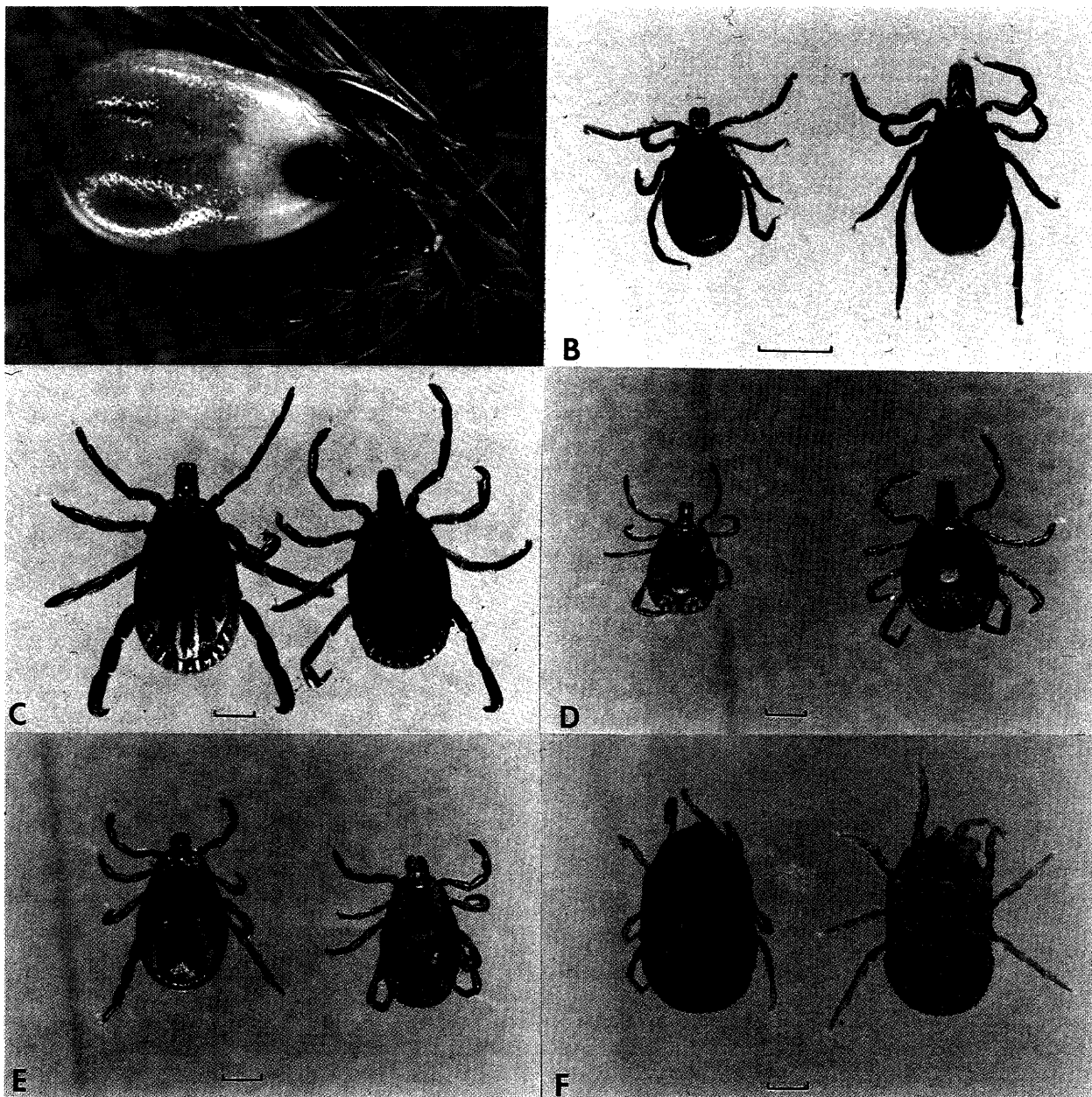
FIGURE 1: Ticks with potential capability of transmitting Lyme disease organisms in Florida. Scale bar on figure is equal to 1 millimeter. A. *Ixodes minor* Neumann, Adult female feeding on wood rat. B. *Ixodes scapularis* Say, The Blacklegged Tick, unfed male left, female right, removed from deer. C. *Amblyomma maculatum* Koch, The Gulf Coast Tick, unfed male left, female right. D. *Amblyomma americanum* (Linnaeus), The Lone Star Tick, unfed male left, female right, removed from deer. E. *Dermacentor variabilis* (Say), The American Dog Tick, unfed male left, female right. F. *Ornithodoros turicata* (Duges), The Relapsing Fever Tick, female dorsal view left, ventral view right.

VERTEBRATE RESERVOIR HOSTS OF *B. BURGDORFERI*: The key element in maintenance of the Lyme *Borrelia* in nature is its sustained presence in reservoir animals. In endemic areas the disease is known to be a zoonosis and includes many potential reservoir animals which place it in close proximity to man and his ecosystem. White-tailed deer and white-footed mouse, *Peromyscus leucopus*, appear to be the primary hosts in the northeastern U.S., but man and a variety of mammals and birds also serve as hosts.

Vertebrate species published as potential North American reservoirs for the Lyme *Borrelia* include the white-footed mouse, *Peromyscus leucopus* (Levine et al., 1985; Magnarelli et al., 1988b; Donahue et al., 1987; Anderson et al., 1987a; Callister et al., 1988); meadow voles, *Microtus pennsylvanicus* (Anderson et al., 1987b); eastern chipmunk, *Tamias striatus* (Anderson et al., 1985); raccoon, *Procyon lotor* (Steere et al., 1983); white-tailed deer, *Odocoileus virginianus* (Magnarelli et al., 1986; Bosler et al., 1984; Telford et al., 1988, who consider deer to be incompetent as reservoirs); cottontail rabbits, *Sylvilagus floridanus* (Telford & Speilman, 1989, & in press;

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Anderson et al., 1989); horses (Magnarelli et al., 1988c); cows (Anon, 1987: PUBL-WM-041 87); dogs (Lissman et al., 1984; Greene et al., 1988); black bears, *Ursus americanus* (Kazmierczak & Burgess, 1989); and some birds, although these probably serve more as disseminators rather than as maintenance reservoirs (Anderson et al., 1986a; Burgess, 1989; Mather et al., 1989). Other mammals, such as the common opossum, *Didelphis virginiana* and the gray squirrel, *Sciurus carolinensis*, have been shown to have antibodies to *B. burgdorferi* (Magnarelli et al., 1984), but their significance as reservoirs is unknown. Ticks which harbor the microorganism and transtadially or transovarially transmit the disease also must be considered reservoirs of the pathogen (Balashov, 1972).

Neither Lyme *Borrelia* reservoirs nor vectors in the southeastern United States have been identified. However, tick species known naturally or experimentally to vector the disease are present throughout Florida (Greiner et al., 1984). One of the potential Florida reservoir species of primary interest, the endangered Florida mouse, *Podomys (=Peromyscus) floridanus*, has been studied recently at Ordway (Franz et al., in preparation). The Florida mouse occupied gopher tortoise burrow presents the mouse as a potential reservoir host and associates it with both hard and soft ticks. The ecology of the Florida mouse, the relapsing fever tick, *Ornithodoros turicata*, and the gopher tortoise habitat has been studied intensively (Milstrey, 1987).

In the United States *Borrelia recurrentis* (louse-borne and tick adapted strains, Harwood & James, 1979) is one of the etiologic agents which causes relapsing fever. Tick-borne borrelia strains are normally named after the vector (Burgdorfer, 1985b; Balashov, 1972). *Ornithodoros turicata*, an argasid, is called the relapsing fever tick (Werner, 1982) and is present throughout the southeastern and southwestern United States (Butler & Gibbs, 1984). The argasid ticks are far more common vectors/reservoirs for *Borrelias* than are ixodids (Balashov, 1972; Hoogstraal, 1979), with nearly 4 times as many species host to *Borrelia* species in nature than are hard ticks. These ticks are present in burrows and nests of many of the potential reservoirs of Lyme disease and may be very important in its epidemiology (Butler et al., 1984; Milstrey, 1987). The potential role of argasid ticks in the epidemiology of Lyme disease remains unknown and should be studied.

POTENTIAL TICK VECTORS: In Florida, potential vector species include the following ticks (Fig. 1): *Ixodes minor* (A); *Ixodes scapularis* (B); *Amblyomma maculatum* (C); *Amblyomma americanum* (D); *Dermacentor variabilis* (E); *Ornithodoros turicata* (F) and *O. talaje*. Both adult and immature ticks present risk of transmission while feeding. The adult and nymphal ticks have eight legs, mite size larval ticks have six. All ticks are parasitic, feeding on the blood of animals in all stages (Dimant & Strickland, 1965). Ticks make a small hole in the skin to feed, attach themselves with a modification of the mouthparts which act as teeth with recurved hooks that are then held in place with specialized glue. A hole is created for blood flow and ticks act as pool feeders. The presence of ticks is annoying to humans as well as other animals, but may go unnoticed for hours, which is enough time to transmit the organisms present within the salivary or gut system.

EPIDEMIOLOGY: Lyme disease is caused by tick bite transmission of a spiral bacterium, *Borrelia burgdorferi*. This disease is difficult to diagnose as the symptoms frequently mimic those of other conditions or they don't appear at all. The sometimes-delayed symptoms in man often make diagnosis and treatment difficult, emphasizing the need to identify and regulate the vector contact with man. The disease usually passes through several stages. Stage I phase includes erythema chronicum migrans or ECM. This appears as an enlarged ring of redness several inches in diameter with a central puncture or mark from the original bite. It usually disappears in about 4 weeks, but may last for months. Flu-like illness with fever, fatigue, headaches, a stiff neck, and muscle and joint spasms may be evident in some patients. Stage II occurs from several weeks to months later in about 60 percent of patients. It may involve many joints, most preferentially the knee. About 15 percent of untreated patients develop neurological disturbances which may include headaches, meningitis, paralysis of facial muscles, or other neurological finds. Heart problems occur in a few patients and may cause irregular heartbeat, dizziness, or fainting. Stage III is the most serious stage occurring in a small number of untreated patients a month to years after initial tick bite. It may consist of progressive arthritis, intellectual deterioration, or psychiatric disease (Benzaia, 1989).

SYMPTOMS: Although the most common pattern is a circle or oval two to three inches in diameter, the rash can appear in other shapes and sizes, including S-shaped. It usually does not itch, but it may feel warm to the touch. Often it is followed within a week or two by flu-like symptoms, including muscle and joint aches, fever, and night sweats. A test is particularly important if you live in or have visited an area where Lyme disease occurs. The diagnostic tests currently available are not foolproof. Antibodies produced as a response to infections may not register positive if you have had antibiotics in the meantime (McKenna, 1989).

TREATMENT: Antibiotics are effective in treating Lyme disease. In early disease, oral penicillin or tetracycline derivatives are the treatments of choice. In later stages, intravenous antibiotics may be necessary. This is a serious health problem. If you should have any of Stage I symptoms, see your physician promptly. Lyme disease reveals itself through antibodies in the blood. But they don't appear in quantity for 4 to 6 weeks, so standard blood tests are useless in the early stages. However, a new generation of blood tests should be more precise. A urine test for the presence of Lyme spirochetes also is being developed (Benzaia, 1989). Wickelgren

reported that spinal fluid can provide answers to an assortment of central nervous system (CNS) ailments due to Lyme disease infection (Wickelgren, 1989).

CONTROL AND PROTECTION: Prevention of tick-human contact is the best control procedure. This is controlled in endemic regions of the disease by avoiding wooded or grassy areas, particularly if they are inhabited with deer, which may harbor vector ticks. Keep clothing buttoned, wear long sleeved shirts, shirts inside pants, long pants, and pull your socks over your pant legs so ticks can't attach to exposed skin. Examine your body for ticks and remove any with a pair of tweezers by grasping the tick as close to the mouth as possible and gently pulling it away from your skin. It is preferable to remove a small amount of skin at the tick attachment site to prevent breakage of the mouthparts in the host (Fig. 1A). This prevents host reaction to tick parts and secondary infection from masking early Lyme disease symptoms, as well as forcing tick fluids and potential tick-vectored organisms into the bite site as other methods of removal tend to do. Early removal of any attached tick reduces the chance of the disease organism being transmitted (Piesman et al., 1987). Do not sit on the ground or logs in bushy areas. Keep brush cleared or burned along frequently traveled areas. Repellents such as DEET (diethyl toluamide), methyl phthalate, dimethyl carbate, or ethyl hexandiol will protect exposed skin. However, ticks will crawl over treated skin to untreated parts of the body. In the southern regions of the country, ticks are present as problems for at least 9 months of the year. Ticks seem to be seasonal, depending on the species present for the region (Koehler & Short, 1980).

Chemical control of ticks is difficult and requires expertise for each potential tick vector species present. Contact your local Agricultural County Agent for current recommendations for your area.

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