TECHNICAL INFORMATION MEMORANDUM NO 26.

TICK-BORNE DISEASES:

VECTOR SURVEILLANCE AND CONTROL

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DISCLAIMER

Mention of specific insecticides, equipment items, or other materials does not constitute an official endorsement by the U. S. Armed Services. Further, the Armed Forces Pest Management Board does not endorse specific brands of any such insecticides or other materials.
FOREWORD

This Technical Information Memorandum, written in order to consolidate information and procedures concerning the surveillance and control of vectors of tick-borne diseases, is being made available to military and civilian agencies having interest in these diseases. As the distribution and magnitude of tick-borne diseases become better known, updating of the information in this TIM will become necessary. In light of the current pace of research on these diseases, I fully expect that our Board will need to revise this TIM in a very short time. Your constructive comments are most welcome and will be given full consideration in the updating of this document.

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I. INTRODUCTION

A. Background

1. Ticks are among the most important of all arthropod vectors of disease. Worldwide, ticks are second only to mosquitoes in the number of diseases they transmit to humans. In the United States, ticks are responsible for more human disease than any other arthropod group.

2. In recent years, the severity of tick-borne disease transmission has been increasing in the United States, both in terms of the incidence of some diseases and the number of known pathogens transmitted by ticks. Tick-borne pathogens appear to be in the vanguard of a group of newly emerging diseases. Since 1957, at least 14 new disease agents have been discovered worldwide. Four of these, or almost 30%, are transmitted by ticks. Most recently, a possible new species of *Ehrlichia* was diagnosed in the upper Midwest. This pathogen caused the deaths of two of the 12 patients it infected.

3. Lyme disease, or Lyme borreliosis, was first diagnosed in the United States in the 1970s. Between 1980 and 1990, the number of reported cases of Lyme borreliosis increased from less than 500 per year to more than 8,000 per year. It is now the most commonly reported arthropod-borne illness in this country. In addition, several other tick-borne pathogens are endemic to the United States, including tularemia, Rocky Mountain spotted fever, and tick-borne relapsing fever.

4. Tick-borne diseases represent potentially serious health threats to troops, civilian employees, and residents at military installations in many parts of the world. Direct effects on the mission (troop morbidity) as well as indirect effects (illness in dependents or DoD civilian personnel and related health care costs) may be lessened through aggressive public education, surveillance, and prevention/control programs, as well as prompt diagnosis and treatment.

B. Purpose of the Technical Information Memorandum

1. To familiarize preventive medicine personnel with the various diseases transmitted by ticks in the United States.

2. To provide a surveillance protocol to evaluate the current and potential threat of tick-borne diseases at military installations.

3. To describe methods for personal protection against tick-borne diseases.

4. To describe reliable control alternatives, both chemical and non-chemical, for reducing populations of tick vectors.
C. Specific Objectives. This Technical Information Memorandum is written to give direction and guidance in specific areas to Pest Management Professionals, such as:

1. Determining whether or not the known or suspected tick vector(s) of disease are present on a military installation.

2. Determining the infection rate in these vectors.

3. Ascertain the presence of other tick species at the installation, and evaluating their possible role in disease epizootiology.

4. Collecting sera from available mammal hosts of tick vectors, and determining sera infection prevalence of tick-borne pathogens.

5. Identifying habitats at the installation that present a high risk of human exposure to infected ticks.

6. Assessing the potential spread of tick-borne disease agents onto or within the installation, based on the existence of suitable habitats, vector ticks and wild mammal hosts.

7. Providing assistance in tick-borne disease education for installation personnel and dependents.

8. Gathering information on the epidemiology of tick-borne diseases in humans, their domestic pets, and other animal hosts.

9. Recommending or performing appropriate prevention/control measures based on surveillance data, the environment, the mission of the installation and other pertinent factors.

II. BASIC TICK BIOLOGY

A. Classification

1. Ticks, and their relatives the mites, are members of the class Arachnida, subclass Acari. Ticks are similar to spiders in that both groups lack abdominal segmentation. However, in spiders the mouthparts are inserted anteriorly on a cephalothorax, which comprises the fused head and thorax. Legs are also borne on the cephalothorax, which is connected to the abdomen by a narrow pedicel. In contrast, the mouthparts of ticks form a discrete anterior gnathosoma or capitulum, and that part of the body on which the legs are inserted (the podosoma) is broadly joined to the portion of the body behind the legs (the opisthosoma) to form the idiosoma.

2. Ticks belong to the superfamily Ixodoidea, which is divided into two major
families, Ixodidae and Argasidae, and the family Nuttalliellidae, which consists of a single rare African species. The family Ixodidae, or hard ticks, contains about 660 species. As adults, these ticks exhibit prominent sexual dimorphism: a sclerotized plate called the scutum covers the entire dorsum in males, but in females (and immatures) the scutum is reduced to a small shield behind the capitulum that permits great distention during blood feeding.

3. The family Argasidae, or soft ticks, contains about 140 species. They exhibit no obvious sexual dimorphism. Argasids lack a scutum, their integument is leathery and wrinkled, and their mouthparts are not visible from above.

B. Life History

1. All ticks have a six-legged larval stage, one or more eight-legged nymphal stages, and an eight-legged adult stage. Ixodid (hard) ticks have a single nymphal stage, while argasids (soft ticks) may have as many as eight. In both families, all stages and both sexes of adults feed on blood. Hard ticks generally take one blood meal per stage, followed by molting, and in the adult stage the female oviposits and dies following the blood meal. The male feeds little, if at all, and dies following mating. Soft ticks feed intermittently, and adult females may feed and oviposit several times.

2. Ticks show great variety in host relationships. They are commonly classified as being "one-host," "two-host," "three-host," or "many-host" ticks. One-host ticks complete all feeding and molting on a single animal. This strict host specificity is not common among ticks. In two-host ticks, the molt from larva to nymph takes place on the host, and the engorged nymph drops to the ground following feeding, where it molts to the adult stage. The adult must then find a second host. Three-host ticks leave their host after engorging at each life stage, all molts taking place off the animal. A variety of species may be utilized as hosts by various life stages, increasing the number of potential sources of pathogens. Most ixodid ticks are of the three-host type. Many-host ticks feed on a number of different animals during their life cycle, with the adult feeding several times. This type of behavior is typical of most of the soft ticks.

3. Copulation takes place after the last molt. In soft ticks, this occurs away from the host. Following copulation the female engorges and produces eggs. Eggs are laid on the ground or in some sheltered location. Female hard ticks lay their eggs in one large batch, which may number several thousand eggs, then die. Female soft ticks lay several smaller batches of eggs, from less than a hundred to several hundred at a time.

4. Ticks are extremely hardy and can survive long periods of stressful environmental conditions. Some species have been known to survive for several years without a blood meal. Eggs, as well as motile stages, can tolerate long periods of submersion in water. They have developed a number of adaptations to limit water loss, and soft ticks in particular are resistant to desiccation, often inhabiting dry, desert environments.
C. Behavior

1. Hard ticks and some species of soft ticks seek their hosts by climbing vegetation, either grass or brush, and waiting for a suitable animal to pass. The first pair of legs is extended and used to grasp the host when contact is made. This behavior is known as questing. The height at which questing takes place determines the size of the host, and therefore the species, selected. There is considerable variation between species, and among the different life stages of some species, in the height at which they quest.

2. Many soft ticks, in contrast, inhabit caves, dens, stables, and other places used by potential hosts. They typically secrete themselves in loose soil or cracks and crevices by day, and attack their host at night, usually while it is asleep. They crawl to the host, engorge in a few minutes or hours, and return to their hiding place.

3. All ticks orient to potential hosts in response to products of respiration. Carbon dioxide, in particular, is attractive at a distance. This characteristic is helpful in surveillance studies because many species can be collected using traps baited with dry ice.

D. Vector Potential

1. Several characteristics of ticks make them outstanding vectors of pathogenic agents. Their wide host range and tendency to feed on several hosts during their lifetime ensures ample opportunity to acquire and transmit pathogens. Their hardness and longevity allow them to survive periods of unfavorable environmental conditions. They have a high reproductive potential, ensuring large populations and a high frequency of host-vector contact. Finally, they feed slowly and, in the case of ixodids, attach to the host for relatively long periods. This allows sufficient time for pathogen acquisition and transmission as well as vector dispersal by migrating hosts.

2. Ixodid ticks are responsible for transmission of the majority of tick-borne diseases of humans in the United States. They are the vectors of babesiosis, Colorado tick fever, Lyme borreliosis, Rocky Mountain spotted fever, and tularemia. While argasids do not directly transmit these diseases to man, they may be involved in the maintenance of natural cycles among reservoir hosts, as in the case of Colorado tick fever. In addition, soft ticks of the genus *Ornithodoros* are the vectors of tick-borne relapsing fever.

III. DISEASES TRANSMITTED BY TICKS IN THE UNITED STATES

A. Babesiosis

1. Causative Agent and Distribution. Human babesiosis is an uncommon infection caused by several species of blood-invading, malaria-like protozoans in the genus *Babesia* that collectively are known as piroplasms. The disease is found mainly in temperate regions of the Northern Hemisphere and was first recognized in humans in 1957, with the report of a case from
Yugoslavia. The first American case was described in 1968. In the United States, babesiosis occurs chiefly along the northeast coast, where the agent is *B. microti*. The area of endemcity of this species includes Nantucket and other Massachusetts islands, New York's Shelter Island, and the coastline of Long Island Sound. A few cases from California have been ascribed to *B. equi*, and a distinct but unidentified *Babesia* was recently isolated from a patient in Washington State. Occasional cases have also been reported from Maryland, Virginia, Georgia, Wisconsin, Minnesota, and as far south as Mexico. In Europe, babesiosis appears to be caused by both *B. microti* and *B. divergens*, with cases reported from Scotland, Ireland, France, the former USSR, and the Yugoslav republics.

2. Symptoms. In humans, *Babesia* infection follows a clinical course similar to malaria but without periodicity. One to four weeks after tickbite, victims experience a gradual onset of malaise, anorexia and fatigue, followed by fever, chills, profuse sweating, headache and generalized myalgia. Asymptomatic infections also occur, though their proportion is unknown. Most patients have no recollection of tick attachment. The clinical spectrum ranges from mild, self-limited illness to life-threatening disease with hemolytic anemia, renal failure and hypotension. Abnormalities resulting from hemolysis and liver dysfunction include persistent anemia, decreased levels of hemoglobin, hemoglobinuria, thrombocytopenia, icterus, and elevated levels of serum hepatic aminotransferase and lactate dehydrogenase. European strains of *Babesia* appear to be more virulent than strains found in the United States, where less than 10% of patients have died (usually elderly persons infected with *B. microti*). Interestingly, about 20% of patients with babesiosis show clinical and serologic evidence of concurrent Lyme disease.

3. Vectors and Transmission. In the northeastern and midwestern United States, *B. microti* is transmitted during summer months by nymphs of the black-legged tick, *Ixodes scapularis*. Along the Pacific Coast, where *I. scapularis* does not occur, the western black-legged tick, *I. pacificus*, is a presumptive vector. Other species of North American *Ixodes* also may be involved. In Europe, the principal vector is the widespread sheep or castor bean tick, *I. ricinus*, though *I. trianguliceps* is also known to transmit infection.

4. Reservoirs. Human babesioses are passed transstadially but not transovarially in vector ticks; therefore, tick larvae can only acquire infection by feeding on reservoir hosts. In the northeastern United States, the white-footed mouse, *Peromyscus leucopus*, and meadow vole, *Microtus pennsylvanicus*, are competent reservoirs of *B. microti*, readily infecting larvae of *I. scapularis*. Along the Pacific Coast, reservoirs have not yet been identified. In Europe, cattle serve as a reservoir of *B. divergens*.

**B. Colorado Tick Fever**

1. Causative Agent and Distribution. Colorado tick fever (CTF), or mountain fever, is an acute viral dengue-like illness caused by a *Coltivirus* in the family Reoviridae. First
described in 1850, CTF is the only common tick-transmitted viral disease in North America, occurring in areas above 1525 m throughout the mountain West, including Alberta and British Columbia, Canada, the various mountain chains of California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming, and the Black Hills of South Dakota. Between 200 and 300 cases are reported annually in the United States, mostly from Colorado, but the actual yearly incidence is probably much higher. Victims are usually people engaged in recreational activities in mountain pine forests, forested canyons, or along rivers and streams in narrow, cultivated mountain valleys.

2. Symptoms. CTF is frequently biphasic. After an incubation period of 3-6 days, the first phase of illness generally begins with abrupt onset of fever, chills, severe headache, eye pain, photophobia, myalgias, sore throat and nausea. These symptoms persist for 5-8 days and, after a brief remission, recur within 3 days in about 50% of patients. In the course of infection, a transient petechial or macular rash may appear. Hematologic abnormalities include leukopenia and thrombocytopenia. The virus develops in most internal organs and may give rise to rare complications, such as encephalitis, aseptic meningitis, hemorrhage, pericarditis, orchitis, atypical pneumonitis, and hepatitis. Encephalitis and severe bleeding are typically seen only in children. Though sometimes depicted as a mild illness, convalescence can be prolonged, and some patients take several weeks to fully recover. Mortality is rare, usually less than 0.2% of reported cases.

3. Vectors and Transmission. The primary vector is the Rocky Mountain wood tick, *Dermacentor andersoni*, whose range is coextensive with that of the disease. Other tick species from which the virus has been isolated include *D. albipictus, D. occidentalis, D. parumapertus, Haemaphysalis leporispalustris*, and *Otobius lagophilus*. Cases have been reported from March to November but most occur from late May to early July, when adult and nymphal ticks are active.

4. Reservoirs. CTF is passed transstadially in vector ticks, but transovarial transmission has not been demonstrated. Unfed nymphs can overwinter the virus, but the chief reservoirs are various small mammals, especially the golden-mantled ground squirrel, *Spermophilus lateralis*, deer mouse, *Peromyscus maniculatus*, bushy-tailed woodrat, *Neotoma cinerea*, least chipmunk, *Tamias minimus*, Uinta chipmunk, *T. umbrinus*, Nuttall’s cottontail rabbit, *Sylvilagus nuttallii*, and porcupine, *Erethizon dorsatum*.

C. Ehrlichiosis

1. Causative Agent and Distribution. Ehrlichioses are caused by several species of minute (0.2-1.5 μm), gram-negative, pleomorphic coccobacilli belonging to the family Rickettsiaceae, tribe Ehrlichiae, genus *Ehrlichia*, which until 1984 were classified in the genus *Rickettsia*. Typically, ehrlichiae infect the cytoplasm of circulating leukocytes via phagocytosis, thus adversely affecting the host's immune system. Until recently, the only species known from
humans was *E. sennetsu*, the agent of sennetsu fever, a rare, mononucleosis-like illness that appears to be confined to western Japan. Human ehrlichiosis in the United States was first diagnosed in 1986 in a 51-year-old Detroit native who had been exposed to ticks in rural Arkansas. In 1990, the agent of this disease was isolated from the blood of a U.S. Army reservist at Fort Chaffee, Arkansas; the next year, it was described as a new species, *E. chaffeensis*, or human monocytic ehrlichiosis (HME). To date, this infection has been reported from 30 states, chiefly in the Southeast, south-central and mid-Atlantic regions, particularly Oklahoma, Missouri and Georgia. In 1994, a third type of human ehrlichiosis, termed human granulocytic ehrlichiosis or HGE, was reported in 12 patients from Minnesota and Wisconsin, two of whom subsequently died. The agent of HGE has not been named but, unlike *E. chaffeensis*, this species commonly invades granulocytes.

2. Symptoms. Sennetsu fever is characterized by sudden onset, with fever, chills, headache, malaise, muscle and joint pains, sore throat and sleeplessness. Generalized lymphadenopathy with tender, enlarged nodes is common. Lymphocytosis, with postauricular and posterior cervical lymphadenopathy is suggestive of infectious mononucleosis. This is a generally benign disease; no fatalities have been reported. In the United States, ehrlichiosis caused by *Ehrlichia chaffeensis* and HGE ranges from illness so mild that no medical attention is sought to severe, life-threatening or fatal disease. After an incubation period of 1-21 (mean 7) days, ehrlichiosis usually presents as a nonspecific febrile illness that resembles Rocky Mountain spotted fever except that a maculopapular or petechial rash develops in only 20-33% of patients, versus over 80% of patients with Rocky Mountain spotted fever. Moreover, the rash caused by ehrlichiosis occurs on the palms of the hands or soles of the feet in less than 5% of cases. Characteristic clinical features are high fever and headache, but other common symptoms include malaise, myalgia, nausea, vomiting and anorexia. Severe and sometimes fatal complications may ensue, most notably acute renal failure, encephalopathy, and respiratory failure. Common abnormalities, which are transient and most pronounced 5-7 days after onset, include leukopenia, absolute lymphopenia, thrombocytopenia, elevated levels of serum hepatic aminotransferase and, rarely, neutropenia or cerebrospinal fluid pleocytosis. On average, patients with ehrlichiosis are older than those with Rocky Mountain spotted fever and males are infected more often than females. About 75% of cases are reported from May through July, and approximately 90% of patients have a history of tick exposure in the three weeks preceding illness.

3. Vectors and Transmission. Cases of sennetsu fever are associated with swampy areas but the mode of transmission remains unknown. *Ehrlichia chaffeensis* has been detected in both the American dog tick, *Dermacentor variabilis*, and the lone star tick, *Amblyomma americanum*, but the range of the latter tick species is strikingly coextensive with that of human ehrlichiosis and PCR analyses have demonstrated *E. chaffeensis* DNA in adult *A. americanum* from six states. Moreover, *A. americanum* has been specifically identified as the source of tick bites among HME patients. Eight of the 12 patients diagnosed with HGE in the upper Midwest had a history of tick attachment ascribed to *D. variabilis* or the black-legged tick, *Ixodes scapularis*, which are candidate vectors.
4. Reservoirs. Unknown for sennetsu fever. White-tailed deer, *Odocoileus virginianus*, are natural reservoir hosts for *E. chaffeensis* and may serve as a source of infection for *A. americanum* in all life history stages.

D. Lyme Borreliosis

1. Causative Agent and Distribution. Lyme borreliosis, generally called Lyme disease but also described as erythema chronicum migrans, tick-borne meningopolyneuritis and Bannwarth's syndrome, is the most common vector-borne infection of humans in the temperate Northern Hemisphere, including North America, Europe and northern Asia. In the United States, Lyme borreliosis was first recognized during the mid-1970s in the vicinity of Old Lyme, Connecticut; since then, it has been reported from virtually all states, though over 90% of confirmed cases have occurred along the Northeast coast (Massachusetts to Virginia), in the upper Midwest (especially Wisconsin and Minnesota) and in northern California. The etiologic agent, the spirochete bacterium *Borrelia burgdorferi*, was not discovered until 1981, but cases of this disease have been described in European medical literature since 1883. Reports of a Lyme-like syndrome in South America, Africa, tropical Asia and Australia are frequently published, but most are based on dubious serologies and none have implicated a vector.

2. Symptoms. Lyme borreliosis has been called "the great imitator" because of its protean manifestations. Within 1-3 weeks of tickbite, a characteristic macular dermatitis called erythema migrans (EM) or erythema chronicum migrans (ECM) develops at the site of tick attachment--but only in somewhat over 60% of cases. Most patients have just one EM, but 25-50% may experience multiple lesions. Vague flu-like symptoms (low-grade fever, headache, fatigue, arthralgias, myalgias, and regional lymphadenopathy) may precede or accompany EM formation, but asymptomatic infections also occur. Without antibiotic treatment, any EM and associated symptoms typically disappear in 3-4 weeks. Untreated patients may show no further signs of illness or they may develop late Lyme borreliosis one to several months afterward. Late disease is characterized by neurologic abnormalities (including the clinical picture of aseptic meningitis, encephalitis, chorea, cerebellar ataxia, cranial neuritis with facial palsy, motor or sensory radiculoneuritis and myelitis; 15-30% of patients), cardiac abnormalities (including atrioventricular block, acute myopericarditis or cardiomegaly; less than 10% of patients), and musculoskeletal complaints, especially arthritis of the large joints (about 60% of patients), but these manifestations apparently vary regionally with strains of the spirochete and may also be dependent on immunogenetic factors.

3. Vectors and Transmission. All known primary vectors of Lyme borreliosis are members of subgenus *Ixodes*, genus *Ixodes*. In North America, these are *I. scapularis* in the East and upper Midwest (the northern form of *I. scapularis* was formerly known as *I. dammini*), and *I. pacificus* in the West. In the Old World, the West European vector *I. ricinus* extends into Eastern Europe and European Russia, where its range overlaps that of *I. persulcatus*, the principal vector throughout Palearctic Asia, including Japan. Various other *Ixodes* that seldom bite humans
or are not members of subgenus *Ixodes* may serve as enzootic or maintenance vectors of *B. burgdorferi*, e.g., *I. dentatus* in eastern North America, *I. spinipalpis* (including its junior subjective synonym *I. neotomae*) in western North America, and *I. (subgenus Partipalpiger) ovatus* in Japan. As well, certain ticks in other genera, such as *Amblyomma americanum* in the eastern and south-central United States, by virtue of their abundance, wide distribution and lack of host specificity, may occasionally become infected with and transmit *B. burgdorferi* to humans, even though experimental evidence indicates that they are inefficient vectors. Spirochetes have also been detected in mosquitoes, deer flies and horse flies in both the northeastern United States and Europe, though the role of insects in the transmission of *B. burgdorferi* appears to be minimal. In North America, most cases of Lyme borreliosis result from the bites of nymphal ticks, which are chiefly active during late spring and summer. In Asia, however, adults of *I. persulcatus* are most often involved in transmitting borreliae to humans.

4. Reservoirs. Rodents, insectivores and other small mammals maintain spirochetes within their tissues for prolonged periods, if not for life, and readily infect larval ticks that feed on them. Infection is then passed transstadially to nymphs and adults. In North America, the white-footed mouse (*Peromyscus leucopus*), dusky-footed woodrat (*Neotoma fuscipes*) and California kangaroo rat (*Dipodomys californicus*) are important reservoir hosts, while field mice and voles in the genera *Apodemus* and *Clethrionomys* are the chief reservoirs across Eurasia. The white-tailed deer (*Odocoileus virginianus*) of eastern North America that are so important as hosts of adult *I. scapularis* are incompetent as reservoirs of borreliae. And it is important to note that less than 1% of unfed tick larvae have been found infected with *B. burgdorferi*, indicating that transovarial transmission is of little consequence in the maintenance of Lyme borreliosis in nature.

E. Rocky Mountain Spotted Fever

1. Causative Agent and Distribution. Rocky Mountain spotted fever (RMSF), known over its vast range by many other names (tick fever, tick-borne typhus fever, black fever, black measles, New World spotted fever, Mexican spotted fever, Tobia fever, Sao Paulo fever), is the most frequently reported rickettsial disease in the United States. RMSF is the prototype of the spotted fever group of rickettsiae and is caused by *Rickettsia rickettsii*, a small (1-2µ long, 0.3µ wide), pleomorphic, obligately intracellular parasite that multiplies freely in the cytoplasm and occasionally in the nuclei of host cells. Though first described in 1872 from residents of the Bitterroot, Snake and Boise River valleys of Montana and Idaho, this disease is endemic throughout the continental United States, southern Canada, and western and central Mexico. Infection also occurs in Costa Rica, Panama, Colombia and Brazil. In the United States, most cases are now acquired in the mid- and south Atlantic and south-central states, especially within a triangular area extending from southern New Jersey and the Carolinas westward to the vicinity of Tulsa, Oklahoma. Most infections arise from exposure in rural or suburban environments, but urban foci exist, as demonstrated by a recent outbreak in New York City.
2. Symptoms. The incubation period, 2-5 days in severe infections and 3-14 in milder cases, is followed by abrupt moderate to high fever, malaise, deep muscle pain, severe frontal and occipital headaches, chills, conjunctival injection, and vomiting. The most characteristic and constant symptom is a maculopapular rash that appears from the second to the fifth day after the onset of other symptoms on the wrists, ankles and, less commonly, the back, later spreading to all parts of the body. Rickettsiae multiply in the epithelial linings of capillaries, smooth muscle of arterioles, and other blood vessels; therefore, death may occur at any time during the acute clinical phase (9-15 days after onset of symptoms) as a result of disseminated intravascular coagulation caused by widespread rickettsia-induced vasculitis. Sequelae in recovered patients may include cardiac abnormalities, loss of motor coordination, paralysis, and loss of fingers or toes due to gangrene. In the absence of antibiotic therapy, the case fatality rate is 15-20%, but even today 2-5% of patients die, chiefly because of misdiagnosis or failure to seek treatment.

3. Vectors and Transmission. Transmitted by the bite of an infected tick or by contamination of abraded skin with crushed tick tissues or feces. The proportion of infected ticks in nature is generally small (1-5%), and most human cases stem from the bites of adult ticks in late spring and summer (nymphs occasionally transmit infection). In eastern North America, the principal vector is *Dermacentor variabilis*, a parasite of domestic dogs, with the result that most victims are women and children. In western North America, the chief vector is *D. andersoni*, adults of which are associated with large game animals and cattle; consequently, most victims are men engaged in agricultural or recreational activities (western populations of *D. variabilis* are not known to transmit *R. rickettsii*). Throughout its North American range, *Amblyomma americanum* apparently does not play a significant role in the transmission of RMSF, but in Latin America *A. cajennense* is the principal vector of this disease.

4. Reservoirs. Ticks are the primary reservoirs, maintaining infection by transovarial and transstadial passage. Many other tick species help maintain RMSF in nature, especially *Haemaphysalis leporispalustris*, which transmits infection between rabbits throughout North America. Though *R. rickettsii* has been isolated from numerous small and medium-sized mammals, including members of the genera *Didelphis*, *Microtus*, *Peromyscus*, *Sigmodon*, *Spermophilus* and *Tamias*, none of these hosts appear to develop the prolonged rickettsemia necessary to infect feeding ticks.

F. Tick-borne Relapsing Fever

1. Causative Agent and Distribution. Tick-borne relapsing fever is a systemic spirochetal infection, but the taxonomic status of the pathogen is in question. Some authors recognize as many as 14 so-called species of *Borrelia*, each developing in and transmitted by a particular species of argasid tick in the genus *Ornithodoros*; others view all such “species” as tick-adapted strains of the louseborne relapsing fever spirochete *B. recurrentis*. There is great variation in strain pathogenicity, and some strains are highly enzootic, rarely infecting humans.
Morphologically and physiologically, relapsing fever borreliae resemble *B. burgdorferi* but tend to be smaller, ranging from 9-15µ long and 0.2-0.5µ wide. Tick-borne relapsing fever is essentially worldwide in distribution, except for Australia, New Zealand, and Oceania. In its various entities, the disease has been reported from Africa, the Near East, central and southern Asia, eastern Europe and the Mediterranean, and the western United States and Canada south into Central and South America. In the United States, the disease was first recognized in 1915 but remains generally limited to remote, undisturbed areas.

2. Symptoms. Most patients do not report a history of tickbite, but an inconspicuous 2-3 mm pruritic eschar may develop at the bite site. Following an incubation period of about 7 days (range 4-18), tick-borne relapsing fever begins abruptly with high fever, chills, tachycardia, throbbing headache, myalgia, arthralgia, abdominal pain, and malaise. Nausea, vomiting, and diarrhea also may be experienced. Neurologic involvement occurs in 5-10% of cases. A transitory petechial, macular or papular rash develops in 4-50% of cases, usually as the primary fever subsides. Common abnormalities include leukocytosis, an increased erythrocyte sedimentation rate, and thrombocytopenia. In untreated cases, the primary fever lasts 3-6 days, followed by an afebrile interval of about 8 days (range 3-36). Untreated victims can experience 3-10 relapses (range 0-13), with febrile periods followed by afebrile intervals. Generally, the severity of illness decreases with each relapse. Mortality is rare and usually limited to infants and the elderly, but pregnant patients may experience spontaneous abortion or transplacental transmission.

3. Vectors and Transmission. In the western United States and Canada, *Ornithodoros hermsi* transmits *Borrelia hermsii* in forested mountain habitats, generally at elevations over 900 m but sometimes at lower altitudes. In xeric lowlands from Kansas to Mexico, *O. turicata* transmits *B. turicatae* and, rarely, *O. parkeri* transmits *B. parkeri*. Tick-borne relapsing fever is a highly focal infection, often associated with rustic mountain cabins or remote caves where, in the absence of humans, ticks of either sex and in all active stages transmit the disease between small mammals, especially rodents. People become infected when they occupy such shelters, usually during summer months but also at other times of year. Transmission is by the bite of ticks or their infectious coxal gland fluids, from which spirochetes can pass into bite wounds or penetrate unbroken skin.

4. Reservoirs. Long-lived ornithodorine ticks serve as persistent reservoirs, with transovarial and transstadial passage of borreliae, though the extent of transovarial transmission varies among tick species. Once infected, ticks remain so for life. Rodents appear to serve as natural sources of infection for ticks.

G. Tick Paralysis

1. Causative Agent and Distribution. Tick paralysis is believed to be caused by a variety of proteinaceous toxins, specific to different tick species, that are secreted into the host
along with other salivary compounds during tick feeding. In humans and animals, paralytic toxins either block the release of acetylcholine at the synapses or inhibit motor-stimulus conduction. Generally, only female ticks cause paralysis, and they must be attached to a host for several (4-7) days before they begin secreting the toxin in their saliva. This malady has chiefly been reported from North America, Europe, Asia, South Africa and eastern Australia. Historically, the greatest number of cases has occurred in North America, with highest incidence along the border between British Columbia, Canada, and the states of Washington, Idaho and Montana. However, in recent years and for reasons not understood, tick paralysis has all but disappeared from the Pacific Northwest. In the eastern United States, cases have been reported from seaboard areas of Virginia, the Carolinas and Georgia, but there are also records from Kentucky, Tennessee, Mississippi and Oklahoma.

2. Symptoms. This affliction is characterized by an ascending flaccid paralysis. In humans, it usually begins in the legs with muscle weakness and loss of motor coordination and sensation. Paralysis gradually progresses to the trunk, with loss of coordination in the abdominal muscles, back muscles, and eventually the intercostal muscles of the chest. Paralysis of the last-named muscle group is especially serious because it can lead to respiratory failure. Ultimately, the victim may be unable to sit up or move either arms or legs, and chewing, swallowing and speaking may become difficult. The condition progresses rapidly, and death may occur 24-48 hours after onset of symptoms. Recorded mortality rates are 10-12%. Diagnosis simply involves finding an embedded tick, usually at the nape of the neck or in the scalp. After removal of the tick, symptoms generally resolve within hours or days, which suggests that the tick toxin is either rapidly excreted or metabolized. However, if paralysis is advanced, recovery can take weeks or months. No drugs are available for treatment.

3. Vectors and Transmission. Worldwide at least 46 ixodid and argasid species in 10 genera have been implicated in cases of tick paralysis involving humans and domestic or wild animals. However, in North America only five tick species—Dermacentor andersoni, D. variabilis, Amblyomma americanum, A. maculatum and Ixodes scapularis—are known to cause paralysis in humans. In the Pacific Northwest, most cases occur during the spring and early summer, coincident with the adult activity period of D. andersoni. In the eastern United States, cases of tick paralysis in dogs and occasionally in humans have been associated with bites of D. variabilis, but in California this tick apparently produces paralysis only in dogs. Interestingly, even in regions with a high incidence of tick paralysis, only a portion of the female tick population appears to be able to cause this condition. Paralysis ticks often attach at the nape of the neck, where they may be concealed by long hair; for this reason, most victims are girls. Among adults, men engaged in outdoor activities are more likely than women to be affected.

4. Reservoirs. None; tick paralysis does not entail the passage or maintenance of an infectious agent.

H. Tularemia
1. Causative Agent and Distribution. Tularemia, or rabbit fever, is a zoonosis caused by the bacterium *Francisella tularensis*, isolates of which are differentiated epidemiologically and biochemically into two strains: Jellison type A, a highly virulent, sometimes fatal form associated with lagomorphs and ticks that is restricted to North America, and Jellison type B, a less virulent and apparently waterborne form associated with muskrats, water rats, beavers, voles and, in Japan, rabbits that appears to occur throughout the temperate Northern Hemisphere. A third strain may occur in Central Asia. Cases of tularemia have been reported from the Arctic south to Mexico, Venezuela, Turkey, Israel and Iran.

2. Symptoms. Clinical presentation depends mainly on the route of inoculation and virulence of the strain. The most common manifestations of tickborne tularemia are ulceroglandular disease, characterized by an ulcer at the site of tickbite with painful regional lymphadenopathy (usually inguinal or femoral), and glandular disease, characterized by regional adenopathy without ulceration. A typhoidal form, with fever, chills, headache, abdominal pain, and prostration but without skin involvement or adenopathy, can also be tickborne. Other forms of tularemia—oculoglandular, primary pneumonic, and primary oropharyngeal—are presumably not tickborne. The incubation period is related to strain virulence and size of inoculum, the usual time frame being 3-5 days, with a range of one day to two weeks. Classical tularemia is characterized by the sudden onset of fever, chills, headache, myalgia, malaise and fatigue. The severity of illness is highly variable, ranging from mild, afebrile, self-limited disease to rare cases of fulminant septic shock; secondary pneumonia, mild hepatitis, and pharyngitis are common complications. Mortality in uncomplicated tularemia is 1-3% with antimicrobial treatment; typhoidal tularemia and secondary pneumonia are associated with increased morbidity and mortality (5-10%).

3. Vectors and Transmission. Modes of transmission of tularemia to humans are varied and include inoculation of skin, conjunctivae or oropharyngeal mucosa with infected blood or tissue while skinning, dressing or performing necropsies on animals; bites of ticks, fleas, deer flies and mosquitoes; handling or ingestion of insufficiently cooked meat of infected rabbits or hares; drinking contaminated water; inhalation of dust from soil, grain or hay contaminated by infected rodents; handling contaminated animal pelts or paws; and, rarely, bites of animals (cats, dogs, coyotes, skunks, hogs, squirrels) whose mouths were presumably contaminated from eating infected rabbits. In North America alone, *F. tularensis* has been isolated from at least 13 species of ixodid ticks (1 *Amblyomma*, 5 *Dermacentor*, 2 *Haemaphysalis*, 5 *Ixodes*), though the three major vectors appear to be *A. americanum* in the southeastern and south-central United States, *D. andersoni* in the West, and *D. variabilis* in the eastern and central states and parts of the Northwest. Each year, 150-300 cases are reported in the United States, chiefly in Arkansas, Missouri and Oklahoma. Cases occur year-round but peak during the fall and winter rabbit-hunting season and during the summer when people are outdoors and ticks or other vectors are abundant. Most adult victims are male.

4. Reservoirs. Ixodid ticks and numerous wild animals, especially rabbits (*Sylvilagus* spp.), hares (*Lepus* spp.) and rodents, serve as reservoirs of tularemia, though rabbits
and hares may experience high mortality rates during epizootics. Important rodent reservoirs include species in the genera *Arvicola, Castor, Microtus, Mus, Ondatra* and *Spermophilus*. Transstadial passage of *F. tularensis* occurs in vector ticks, but claims that transovarial transmission also occurs require confirmation.

**IV. TICK SURVEILLANCE MEASURES**

**A. General.** There are several tick surveillance methods that can be used to determine the number and types of ticks in a given area, including tick drags, tick walks, dry ice traps and tick collections from animal hosts or their burrows/nests. Whichever methods are chosen, they should be used consistently throughout a given evaluation. Different species and life stages of ticks are collected disproportionately by the various methods, and methods selected must be tailored to the species and life stage desired.

**B. Tick Drags and Tick Walks**

1. **Tick Drags**

   a. Tick dragging collects representative samples of the hard ticks present and is indicative of the actual exposure a person active in the area might experience. This technique is very manpower intensive and yields few ticks in areas of low to moderate tick densities. However, as a quick pre-treatment survey or "spot check" of an area, it is the most practical technique available. This method is particularly useful for adult blacklegged tick (*Ixodes scapularis*) surveillance, since *I. scapularis* surveillance using CO₂ traps requires a lengthy trapping period (see IV.B.1. d. below for immature *I. scapularis* surveillance).

   b. The basic principle involves dragging a piece of soft cloth over or around the vegetation where ticks are waiting (questing) for a passing host. Ticks cling to the cloth. After dragging the cloth over the sampling site in the area of concern, the ticks are removed, counted and identified. Ticks should be sampled and removed in a standardized manner (i.e., every ten paces).

   c. A tick drag can be made from a sheet of soft white material such as muslin, interlining, or flannel, 1 meter long by 1 meter wide. Stapling a 1.2-meter dowel to the leading end of the sheet serves to keep the sheet spread open as it is pulled over vegetation and small obstacles. A 2-meter cord is attached to both ends of the dowel to form a loop, which is used to pull the drag. A second dowel is sometimes attached to the trailing end of the drag, but in dense vegetation this dowel tends to get hung up, and the cloth does not conform to the shape of vegetation as well.

   d. In some cases, a tick flag can be used with greater success than a drag. For example, when ticks quest low in vegetation and leaf litter or in very dense vegetation, a flag
facilitates reaching questing sites. A tick flag is made by attaching a piece of cloth to a stick or dowel to resemble a flag. The flag is waved back and forth under, in and around vegetation or leaf litter. Ticks will quest where they are most likely to encounter their preferred host. For example, immature *I. scapularis* are most commonly found on small mammals (e.g., mice) and are more likely to be picked up by flagging low than by dragging over the tops of vegetation. Similarly, immature *I. scapularis* stay in the leaf litter around a CO$_2$ trap, rather than climbing onto the trap, and can best be collected by flagging the trap area.

2. Tick Walks

   a. Ticks attaching to a person walking in a prescribed area provide the best representative sample for a human active in that area, and analysis of these ticks provides the best information on the threat to humans from ticks. Anyone pulling a tick drag is in effect engaged in a tick walk. Ticks attaching to a person conducting any form of surveillance should not be ignored. White, 100% cotton clothing (pants and shirt, or coveralls, and socks) should be worn to highlight any ticks encountered. If live ticks are required for testing, repellent should not be used, and outer clothing should be sealed (taped) to prevent tick penetration and attachment. The pants are bloused into socks or taped to boots. Low-cut shoes can be worn to provide greater surface area for tick collection on the socks; however, immature ticks not collected from the surface may penetrate the socks and attach.

   b. Surgical stocking net (NSN 6510-00-559-3159) has also been used; it is pulled over the legs of the regular battle dress uniform (BDU). It can then be taped down around the lower part of the boots to prevent ticks from getting under the material. This method is advantageous because there are no special clothing requirements. Even permethrin-treated BDUs can be covered in this fashion. The stocking net will not diminish the effects of the permethrin against ticks.

3. Additional Considerations

   a. Surveillance Sites

      (1) When doing tick surveys, select several different locations. When conducting CO$_2$ surveillance (see below) in addition to other sampling methods, select tick sampling locations near the CO$_2$ traps for comparative samples. Select sampling sites for tick surveillance based on a representative sample of the different habitats available on the installation. Take into account areas of human activity across the installation. A recommended procedure is as follows: If any one habitat type accounts for more than half the outdoor or field activities taking place on the installation, perform 50% of the tick surveillance in that type of habitat, and select the remaining sites according to estimated extent of cover and human activity in each habitat type.

      (2) Note that some habitats contain more ticks than others. Highest tick densities are generally correlated with areas of high mammal activity, such as animal
trails or bedding sites. Edge habitats, as where forests open to fields, trails or clearings, may have the highest tick concentrations, but don't overlook other types of habitat. Seek to maximize captures by selecting areas where tick concentrations are high for tick drags and CO$_2$ traps.

(3) Sampling can be done during different times of the day to improve the chances of collecting at peak tick activity periods. Early mornings may not be a good time for tick collection because of overnight dew and low temperatures, which reduce tick activity. Late morning from 1100-1230 and during the afternoon between 1500-1630 may be better periods to survey. Time of day and weather conditions affect tick activity and the number of ticks collected.

b. Measurements

(1) A fixed distance of 100 meters can be used to standardize drag samples. Cloth or clothing should be examined for ticks every ten paces or so. If the same area is to be sampled repeatedly, engineer flagging can be used to mark the beginning and end of the drag line.

(2) Carry a collection vial, labeled with sample number, site location, and date. Plastic vials preclude breakage. If large numbers of ticks are encountered and additional collection vials become necessary, they should be labeled identically.

(3) Pick off all ticks and place them in the collection vial. Remove adult and nymphal ticks from cloth with a pair of tweezers or forceps. Alternatively, a 2-inch wide piece of tape or lint roller is a good method for quickly removing large numbers of ticks. The tape or roller’s adhesive sheet can then be marked with the date, time, location, collector’s name, and drag distance. Adhering the tape to the inside of a sealable plastic bag containing a piece of moist (not dripping wet) paper towel will keep ticks alive for weeks if they are kept cool. A piece of waxed paper can be placed over the adhesive surface, allowing the tape to be folded on itself when placed into a vial or plastic bag. The ticks can be counted and tentatively identified while still adhering to the adhesive surface, and they can then be removed for further processing.

(4) After all collections are made, place a blade of grass in each vial. The blade of grass provides adequate moisture but not the excessive wetness that often results from using moist paper towels.

(5) Note basic weather conditions, including temperature, on a data sheet (see Appendix J for tick survey forms).

(6) Dragging and tick walks should not be done in the rain, when vegetation is wet, or during times when the air temperature is less than 54°F (13°C). Such conditions usually reduce tick questing and the resultant effectiveness of these methods.
However, activity parameters are species dependent. Adult *I. scapularis*, for example, can be active in winter any time it’s above freezing.

(7) Check Appendix A for the surveillance methods that work best with different tick species.

C. Carbon Dioxide Trapping

1. For many species, carbon dioxide (CO\textsubscript{2}) trapping can yield the most ticks per man-hour expended. This technique relies on the ability of ticks to sense CO\textsubscript{2} and move toward the source. The sensitivity of this method varies with the species of tick. Lone star ticks (*Amblyomma americanum*) are attracted to CO\textsubscript{2} traps to a greater degree than are American dog ticks (*Dermacentor variabilis*). Nonetheless, more American dog ticks can be collected by this method than by dragging, per man-hour expended. *Ixodes scapularis* ticks are also attracted to CO\textsubscript{2}, but 12 to 24 hours of trapping may be required to attract these slower-moving ticks. The CO\textsubscript{2} trapping technique is generally less successful for *I. scapularis* than dragging or small mammal checks. The opportunity to place CO\textsubscript{2} traps in areas of high tick activity greatly influences the success of this method.

2. Procedures

   a. Dry ice is placed in vented, insulated containers. Tape can be attached, sticky side exposed, around the perimeter of the trap to capture attracted ticks. A half pound of dry ice will last about 2 hours at 80°F (27°C) using an insulated container. There are many variations on this theme depending on the tick species to be sampled. Traps have been designed to collect ticks over a 7-day period using a 12-kg block of dry ice. Small traps with tubing to vent CO\textsubscript{2} can be fashioned to sample ticks in burrows or tree nests. For rapidly moving ticks such as *A. americanum*, a piece of dry ice can simply be placed on an inverted pie pan on a white sheet.

   b. Where dry ice is not available, gas cylinders or chemical generation may be used as a CO\textsubscript{2} source for traps. To generate CO\textsubscript{2} chemically, mix 128 g of sodium bicarbonate (baking soda) with 88 g of dry succinic acid in a 1.0-liter chamber having a 1/4-inch (7mm) hole in its side. Insert a 0.5-liter cup with a 1/32-inch (0.75mm) hole in its bottom into the chamber. Activate the CO\textsubscript{2} generator by filling the cup with water.

   c. Setting more than one trap at each collecting site will provide a more reliable estimate of the actual population.

   d. Record date, site (use Defense Mapping Agency map grid coordinates, if possible), time traps were set, time ticks were counted, species and numbers of ticks present for each of the traps at each site (Appendix J). Calculate a trap index (TI) for each site to adjust results for differences in time that traps were operating at various sites. The TI is calculated by adding the total counts from all traps at one site and dividing by the number of traps (usually 3) to
get the average catch for the site. This number is then divided by the time (in hours) that the traps were operating. Time in hours is calculated by dividing the number of minutes of trap time by 60 minutes. For example, 3 traps were set up at a site at 0800 hrs. and ticks were counted at 1000 hrs. The tick counts recorded were 47, 13, and 30. Since a total of 90 ticks were trapped by the 3 traps in 2 hours, the resulting TI would be 15 ticks per trap hour \([(90/3)/2]\). Studies of Lone star ticks conducted in Oklahoma showed that when all stages of ticks are counted, the number of ticks found on a trap per hour approximates the number that would be expected to attach to a human who remained in that spot for an hour (NOTE: If, upon returning to count ticks, you discover that all the dry ice is gone from a trap, disregard the data from that trap and use only the data from the remaining traps to calculate the TI. The uncounted ticks can still be used for other purposes, such as testing).

e. Threshold TIs for the initiation of tick control can be determined by combining information from all available sources and by evaluating the nature and frequency of human use in a given area. On sites used infrequently or for brief periods of time, more ticks can be tolerated than in heavily used recreational areas. In some cases, such as a picnic area in a Lyme endemic area, it may not be unreasonable to use a threshold TI of 1. In another case, such as one adult American Dog tick (easily seen and removed) in a recreational fishing area, a TI of 1 would generally not signal the need for control measures. Rather, personal protection should be emphasized. The threat of potentially vectored disease must also be considered when selecting a TI to signal control measures. The TI is based on local tolerance for ticks.

D. Host Trapping and Examination

1. Host trapping provides the most accurate assessment of a local tick population when appropriate hosts are sampled. While nothing works as well as the natural host to evaluate tick populations, difficulty in catching some wild hosts is a limiting factor with this surveillance technique.

2. Ensure the efficiency and validity of survey measures by thorough coordination, scheduling and preparation. If possible, begin coordination at least 30 days in advance of the anticipated survey.

3. The following is a checklist of pre-survey preparations for tick collections from natural hosts:

   a. Review the Centers for Disease Control publication “Methods for Trapping & Sampling Small Mammals for Virologic Testing” (TIM 40) and “Protection from Rodent-borne Diseases” (TIM in preparation) to determine if resources exist to do small mammal collections.

   b. Contact the installation Environmental Science or Preventive Medicine Office for preliminary coordination. Find out what other personnel should be contacted (e.g.,
natural resources, security, veterinarian, game warden, pest control, range control).

c. Obtain maps [e.g., installation training map (1:50,000) or terrain analysis map (1:50,000)] and geographic information system (G.I.S.) vegetation data in advance, if possible.

d. Solicit recommendations for sampling areas from the personnel listed above based on potential for contact with ticks and known problem spots. If possible, select in advance potential sites for tick walks and small mammal sampling.

e. When sampling small mammals, obtain state trapping permits or determine whether trapping can be conducted under pre-existing permits issued to the installation. Arrange for any necessary permits, as well as outdoor space for processing.

f. Coordinate deer sampling with appropriate personnel, such as the wildlife biologist or game warden. Determine the duration of the hunting season, days when most deer are harvested, and the location of check-in stations.

g. Based on the above coordination, schedule survey dates and prepare a notification letter for the wildlife biologist, game warden or other designated point of contact.

h. Schedule time(s) for presentation of Lyme disease educational material to installation personnel who will be assisting you or who need information for such projects as news releases.

i. Assemble necessary supplies.

4. Since the handling of rodents places one at risk for hantavirus exposure, procedures in the CDC’s ‘Methods for Trapping & Sampling Small Mammals for Virologic Testing’ (TIM 40), ‘Protection from Rodent-borne Diseases’ (TIM in preparation), or other similar protocols should be followed to minimize risk and standardize procedures.

5. The most efficient way to examine deer is to monitor check stations during the hunting season. The following are procedures for collecting ticks from deer:

a. Wear rubber gloves (e.g., disposable surgical gloves or snug plastic work gloves) and coveralls, or other protective clothing, while collecting ticks.

b. Use fine-tipped (e.g., No. 5 jeweler’s) forceps to collect ticks from the head/neck region and ano-genital region. Spend 5 minutes in each of the two areas, recording the number of ticks collected within each 5-minute period. If more time is available, collect more ticks. Priority should be given to collection of unengorged ticks. If no ticks are seen in a given region, the remaining time may be spent examining other areas. Record these collection efforts.
separately (area, number of ticks, amount of time). When collecting from deer, it is useful to have a large white enameled pan in which to place the ticks. Ticks may then transferred to a vial. Use a moistened fine-tipped (000 or 0000 size) artist's paint brush to pick small ticks from the enameled pan.

c. Ticks may be difficult to remove if deeply embedded. Try to keep ticks intact during removal. An intact specimen is needed for species identification, and live specimens are required for laboratory analysis for spirochetes. It may be necessary at times to cut the skin tissue around the ticks, removing both skin and attached ticks.

d. Place ticks in labeled, screw cap, plastic vials that have each been humidified with a piece of grass. When using vials with a water-absorbent base (e.g., plaster of Paris), place several drops of water in each vial to lightly moisten them. Do not put more than 10 fully engorged ticks in a vial, but split the sample among as many vials as needed. Large numbers of engorged females tend to increase mortality in a vial and can destroy the sample.

e. Print the sample number on the label. Preprinted computer labels expedite the process. This number will be in the same format as that described in Appendix J for specimens submitted to Army laboratories.

f. Store tick vials at room temperature. If ticks are being stored for several days prior to shipment, it may be necessary to conserve moisture. This can be done by placing the specimens in a refrigerator. Before refrigeration, the vials should be tightly sealed and placed inside a closed plastic bag containing a moistened paper towel. Do not freeze the specimens.

g. Ship ticks as soon as possible if a Lyme disease analysis is to be performed at another location (Appendix J).

h. Appendix C is a protocol for collecting blood from deer for serological testing.

6. Domestic Animal Surveillance for Ticks

a. Many domestic animals are in close contact with both tick-infested environments and humans and may therefore play an important role in vector-borne disease transmission. Clearly, surveillance of domestic animals may be a good method for determining the presence of tick-borne disease.

b. Dogs may be considered "sentinel" animals in those parts of the world where Lyme disease has yet to be reported. There are several justifications for this strategy:
(1) Dogs, as previously mentioned, are at greater risk of tick infestation and Lyme disease than are humans.

(2) Dogs have a strong, clear-cut antibody response to the spirochete in contrast to the response seen in humans and deer.

(3) Dogs are compliant and easily sampled, particularly in conjunction with heartworm surveys, which are already in place in many parts of the world.

(4) Since dogs frequently develop an asymptomatic condition that may progress to severe lameness, civilian and military dog owners are well motivated to have their animals tested.

(5) Most military bases have veterinary support, which can serve as the coordinating point for on-base and off-base studies.

c. Appendix D is a general canine serology protocol adapted from the former Medical Entomology Laboratory of the New York Medical College. In addition to serological testing, tick collections should be made. Collecting ticks from animals like dogs, cats or birds can sometimes be accomplished with a lint roller. The roller should be moved against the grain of the fur, pressing it as close to the skin as possible. This technique will not work for long-haired animals or for embedded ticks.

E. Tick Identification

1. Once surveillance programs are established, identification of the ticks is necessary. This can be done using a dissecting microscope, with magnification from 60 to 90 times, and a dichotomous key. Keys to the genera of hard and soft ticks are in Appendix E. Keirans and Litwak (1989) have published a pictorial key to the adults of the hard ticks east of the Mississippi River.

2. Many keys are designed for a specific sex or life stage. Always check the particular key you are using to see if any distinction is made between males, females, nymphs or larvae. Adult ticks are the easiest to identify, and mistakes will be made if a nymphal key is used to identify adult ticks. A quick method for differentiating male and female ixodid adults is to examine the scutum (the shield-like structure behind the capitulum). In males, the body is totally covered by the scutum, whereas the female scutum does not extend the entire length of the body.

V. PREVENTION OF TICK-BORNE DISEASES

A. Information Gathering for Tick-borne Diseases
1. Obtain as much information as possible concerning the status of tick-borne diseases at and around the installation. The following is a list of personnel who may have pertinent information:

   a. Preventive Medicine Officer  
   b. Occupational Health Nurse  
   c. Community Health Nurse  
   d. Post Veterinarian  
   e. Local Health Officials  
   f. State Health Officials  
   g. Environmental Science Officer  
   h. Wildlife Biologist  
   i. Entomologist  
   j. Game Warden  
   k. University Researchers

2. Obtain copies of any operational plans, guidelines, existing data and literature prepared by the installation concerning tick-borne diseases.

B. Education

1. Education is a critical tool in preventing tick-borne diseases. It is imperative that personnel learn what diseases ticks transmit on their installation, how to recognize ticks, and how to avoid contact with them.

2. The agencies listed in Appendix F can be contacted for assistance in obtaining information or speakers for the training of medical, pest management, or other personnel.

3. Other educational methods can be utilized:

   a. Making informational brochures/pamphlets/fact sheets a part of the check-in material for in-processing personnel (See Appendix I for examples of such information).

   b. Publishing periodic notices in the installation newspaper or Plan of the Day, particularly during spring and summer periods and the fall hunting season.

   c. Posting warning signs in woods or other areas where ticks have been found, so that troops, hunters or hikers will see them.

C. Personal Protective Measures

1. Ticks are fairly small, especially as immatures, and can therefore easily go
undetected. Twenty to 30% of Lyme disease patients in one study did not recall a tick bite. Since adults, nymphs, and sometimes even larvae are capable of transmitting pathogens, it is extremely important that people be familiar with all the stages of the different tick species found on their installation. See “Personal Protective Techniques Against Insects and Other Arthropods of Military Significance” (TIM 36) for an in-depth discussion of tick barriers and repellents. The following personal protective measures should be emphasized.

2. Tick checks. Check clothing and exposed parts of the body routinely while in tick habitat. Use the buddy system to check areas that you cannot easily see yourself. After leaving tick habitat, carefully recheck your clothes and entire body. Showering may help.

   a. Finding and removing ticks quickly is one of the most effective methods of preventing tick-borne diseases. Ticks take varying amounts of time to search for a desirable spot to attach on the body and usually require additional time to actually transmit pathogens while they are feeding. Prompt detection and removal will lessen their ability to transmit infection.

   b. Ticks are frequently found on the head, neck, groin, and underarms but may be located anywhere on the body, including the torso, arms, legs, and ankles. One study of *Ixodes scapularis* indicated that adult ticks were more prone to position themselves on the head and neck regions (they will travel greater distances on the body), while nymphs and larvae were more frequently seen on the lower extremities.

   c. Proper tick removal is important (See Appendix I).

   d. Tick bites should be monitored and the ticks themselves saved for identification if symptoms develop. Diagnosis of tick-borne diseases can sometimes be difficult. Early symptoms of many diseases are either similar or mimic other conditions, so confirmation of the tick vector species is usually an important clue in the clinical picture. Any individual who has been bitten should be alert for disease symptoms, such as fever, chills, headache, fatigue, muscular and joint aches and pains, and/or rashes up to one month following the bite (See Section III - Diseases Transmitted by Ticks in the United States). If symptoms do develop, seek immediate medical attention. Some tick-borne diseases progress quickly and can be life-threatening (e.g., Rocky Mountain spotted fever), while others progress more slowly but may persist indefinitely if not treated promptly (e.g., Lyme disease).

3. Protective clothing. Proper clothing will decrease access of ticks to the skin, thereby helping to prevent bites. Pants should be bloused or tucked into the boots or socks, and the shirt should be tucked into the pants. This forces ticks to crawl up the outside of the pants or shirt, where they are more likely to be seen. If the uniform shirt cannot be tucked in, the next best thing is to wear an undershirt that is tucked into the shorts. This will serve as a second layer of defense. Long sleeves will help, and a hat will be useful if crouching or crawling in bushes or undergrowth. Light-colored clothing will make ticks much easier to detect. A roller-type
adhesive lint remover is useful for removing ticks from clothing.

4. Repellents. Use of repellents is very important in preventing tick bites. The DoD Arthropod Repellent System is a philosophy that stresses the simultaneous use of both a skin and a clothing repellent--deet and permethrin, respectively--for maximum protection from arthropod attack.

   a. Permethrin is the standard military clothing repellent, and it is the most effective repellent for use against ticks. Since permethrin is actually a contact pesticide, it incapacitates and eventually kills ticks. Permethrin is available through the military supply system in several formulations: a 6-ounce aerosol can used to treat a single military uniform; a 5.1-ounce bottle of concentrate that is dissolved in a 2-gallon sprayer for treatment of 8 uniforms; and an impregnation kit for treatment of a single uniform. Treated clothing should be dried prior to wearing, and permethrin should only be applied to clothing--never to skin.

   (1) Permethrin aerosol (NSN 6840-01-278-1336) contains 0.5% permethrin. The aerosol should be sprayed liberally, to the point of dampness, over the entire outside surface of the uniform (a color change in the fabric indicates wetting; it dries to its original color). When treated with 3/4 of a can, the uniform will provide excellent tick protection through up to 6 launderings. It is especially important to apply permethrin to the lower pant legs, crotch, waistband, shirt sleeves, collar, front placket and lower edge of shirt.

   (2) Permethrin concentrate (NSN 6840-01-334-2666) is used in a 2-gallon sprayer to treat 8 sets of uniforms. When dry, the uniforms offer effective protection for the combat life of the uniform.

   (3) Individual Dynamic Absorption Application kit (IDAA kit, "baggie" method)(NSN 6840-01-345-0237) is used to impregnate a single uniform with permethrin. The kit consists of two small vials of permethrin concentrate, two plastic treatment bags, two pieces of twine, and a black permanent marker. The pants and shirt are treated separately. Each is rolled up, tied with a piece of twine, and placed in a treatment bag into which a vial of permethrin and 3/4 canteen cupful of water has been mixed. After three hours, all the liquid will have been absorbed by the clothing, and it is then hung to dry. The kit imparts effective protection from tick bites for the combat life of the uniform.

   (4) Desert camouflage uniforms are permethrin-impregnated at the factory, and so automatically offer protection from tick attack for their combat life.

   b. Deet (N,N-diethyl-m-toluamide or N,N-diethyl-3-methylbenzamide) is the standard military skin repellent, and it should be used in conjunction with permethrin-treated clothing to provide maximum protection. The extended-duration, or long-acting, formulation (NSN 6840-01-284-3982) is a lotion that contains 33% deet and provides protection for up to 12 hours, depending on environmental conditions. It should be applied in a thin film over exposed
skin surfaces, according to label directions. It is not as greasy, smelly, or destructive to plastics as earlier military formulations of deet.

5. Animals. Companion animals should be closely monitored for ticks on a daily basis. Dogs are particularly vulnerable and have been shown to be several times more likely to acquire Lyme disease than their owners. A number of commercial products are available for controlling fleas and ticks on pets. These products should be used cautiously. To avoid toxic synergistic effects, a veterinarian should be contacted for advice on using more than one type of treatment on an animal. A veterinarian may also provide prescription chemicals.

6. Unauthorized products. The use of flea and tick collars on humans should not be permitted under any circumstances. These collars are labeled for use on animals like dogs and cats, which have few or no sweat glands in their skin, and thus do not absorb chemical toxicants from the collar. Human skin readily absorbs chemicals. People who foolishly wear pesticide-impregnated flea and tick collars risk skin damage or poisoning. Use of other commercial products (e.g., bath oils) in a manner inconsistent with their labeling may be hazardous or may fail to provide protection equivalent to standard military repellents.

7. Prophylaxis. Several prototype human Lyme disease vaccines are under development. A canine Lyme disease vaccine is currently available. Neither vaccines nor prophylactics are available for other tick-borne diseases.

8. Summary. Properly worn clothing, skin and clothing repellents, and frequent personal tick checks remain the best regimen for preventing tick-borne diseases.

V. TICK CONTROL MEASURES

A. Integrated Control Measures

1. The control measure(s) selected should be tailored to the biology and seasonality of particular tick species (see section II. B. of this TIM). Equally important, all tick control efforts must be compatible with environmental concerns and human safety.

2. Additional considerations include the type of habitat involved, density and activity of the human population, incidence of infection in the vector species, extent to which tick control is necessary, and degree of environmental modification that is permissible.

3. Based on a knowledge of when the infected stages are most active and abundant, the medical or installation authority may recommend complete avoidance of some areas at certain times.
4. Integrated tick control comprises four distinct categories: habitat modification, acaricide application, deer exclusion, and personal protection. These various approaches can effectively control ticks. Figure 1 outlines which methods are most appropriate for areas requiring control.

<table>
<thead>
<tr>
<th>TYPE AREA TO BE CONTROLLED</th>
<th>RESIDENTIAL</th>
<th>RECREATIONAL</th>
<th>PRESERVE</th>
<th>WILDERNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEGREE OF HUMAN ACTIVITY</td>
<td>![Icon]</td>
<td>![Icon]</td>
<td>![Icon]</td>
<td>![Icon]</td>
</tr>
<tr>
<td>CONTROL MEASURE</td>
<td>+</td>
<td>+</td>
<td>+ / -</td>
<td>-</td>
</tr>
<tr>
<td>Habitat Modification</td>
<td>+</td>
<td>+</td>
<td>+ / -</td>
<td>-</td>
</tr>
<tr>
<td>Acaricide Application</td>
<td>+</td>
<td>+</td>
<td>+ / -</td>
<td>-</td>
</tr>
<tr>
<td>Deer Exclusion</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Personal Protection</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Figure 1. Appropriateness of Tick Control and Personal Protective Measures.

B. Habitat Modification

1. Clearing of edge habitats by leaf litter removal, mechanical brush removal, mowing and/or burning vegetation, where acceptable, represents an effective means of tick control in residential areas, bivouac sites and certain recreational areas. Removal of low-growing vegetation and brush eliminates the structural support that ticks need to contact hosts, thereby reducing the incidence of tick attachment. Removing leaf litter and underbrush also eliminates tick habitats and reduces the density of small mammal hosts, like deer mice and meadow voles. Without leaf litter, ticks are denied suitable microhabitats that provide the necessary environmental conditions for survival, such as high relative humidity. Mowing lawns and other grassy areas to less than 6 inches (16 cm) greatly reduces the potential for human-tick contact. Of course, the environmental consequences of habitat modification must be thoroughly evaluated to avoid creating additional problems.

2. Controlled burning, where environmentally acceptable, has been shown to reduce tick abundance for six months to one year. Besides killing all active stages, burning also
reduces questing success by destroying the vegetation that is normally used to contact passing animals or humans. The degree of success in controlled burning is dependent on several factors: the amount of combustible brush and ground cover present, the environmental and climatic conditions at the time of burning, the size of the area to be burned, tick activity, and the rate of tick reintroduction due to animal utilization. There must be a critical mass of combustible material in an area to support an effective controlled burn. The moisture content of the ground cover (leaf litter) and standing vegetation must be low enough to allow a thorough burn. It is best to burn in the late evening when ambient humidity is higher and winds are minimal. These conditions favor a slower burn that consumes some of the protective ground cover and permits penetration of high temperatures to the lower levels of unburned cover or leaf litter. Burning when winds are high increases the risk of wildfire and greatly reduces the consistency and effectiveness of the controlled burn. Success can also be affected by the size of the area burned. Depending on the ecological situation, fires in areas of less than 5 acres (2 hectares) normally provide only temporary reductions in tick numbers due to the rapid reintroduction of ticks by animals passing through the burned site or the reestablishment of animal populations in the burned area. Even large controlled burns may provide only a temporary decrease in tick populations. In some instances, if the amount of vegetation in an area is not regulated, controlled burns may actually increase the browse available for deer, thus eventually increasing the tick population above pre-burn levels. Success in habitat modification is largely dependent on removal of ground cover, especially the mulch that gives shelter to all tick stages. Burns can be conducted in the winter when trees are dormant to avoid damage to timber resources. All burning efforts must first be coordinated through proper installation channels.

3. Simple mechanical clearing of underbrush, to the extent that it allows 70-80% sunlight penetration, is an effective means of reducing deer tick numbers. In developed areas, frequent mowing of grass will definitely help control tick populations. If mechanical clearing is accompanied by herbicide application, larval populations may be reduced by 90% and adult and nymphal populations may decline by 50% or more. Like burning, the success of this technique is dependent on various ecological and environmental factors and control procedures: the amount of vegetation removed, the size of the area, tick activity, the amount of tick reinfestation due to animal utilization, and the extent to which control procedures are maintained. Clearing also helps reduce the attractiveness of these habitats to small mammals, birds and deer. As with controlled burns, the smaller the area cleared, the faster it is likely to be reinfested by ticks. In order to reduce tick populations to acceptable levels, vegetation control must be practiced on a regular basis. In most instances, control by mechanical means will be the preferred technique because it does not contaminate the environment with pesticides. However, this method is labor intensive and only slowly reduces tick populations.

4. Another habitat modification technique is to thin early successional vegetation and grasses in early to mid-fall, stressing the overwintering tick population and reducing survivability. This should be accomplished late enough in the season so that regrowth will not provide sufficient winter cover for ticks.
C. Acaricide Application

1. The use of an acaricide, or any other pesticide, must be consistent with label requirements of the Environmental Protection Agency (EPA) and the Federal Insecticide, Fungicide and Rodenticide Act of 1972, as amended. Outside the jurisdiction of the EPA, DoD Directive 4150.7 requires that pesticide application be in accordance with the accepted standards of the host country, or any host-tenant agreement between the United States and that country. In the absence of any host country standards and agreements, the application must be consistent with EPA requirements or the regulations of the respective service, whichever are more stringent. Beyond these requirements, pesticide selection and application should be in accordance with the recommendations set forth in Technical Information Memorandum 24, “Contingency Pest Management Pocket Guide,” available from the Armed Forces Pest Management Board. Area chemical treatments should be a last resort in tick control operations.

2. Experience has shown that applications of liquid pesticides to control ticks may be impractical because of incomplete penetration of vegetation, especially when aerial dispersal is employed. However, adult *Ixodes scapularis* generally quest in the shrub and grassy layer after the autumn leaf drop and again in the spring before leaves reappear. The lack of protective foliage during these periods makes adults of this species vulnerable to chemical sprays. Effective control of deer ticks in all stages has been achieved in small areas using a backpack sprayer or hand-operated granule spreader, thereby also reducing environmental contamination of nontarget areas. But such applications are very labor intensive and are unsuitable for larger areas. As well, small areas may require frequent retreatment because ticks may be quickly reintroduced by animal hosts. Seasonal applications of acaricides target overwintered nymphs as they become active in the spring and early summer and possibly larvae in late summer or early fall. Large-scale applications using vehicle-mounted air-blast sprayers or aerial dispersal of liquid or granular pesticides have provided 50-90% control for 6-8 weeks.

3. The formulation (e.g., dust, granule, emulsifiable concentrate) is one of the primary considerations in selecting the type of equipment that will be used to apply an acaricide. In addition, the formulation may be a very important factor in limiting pesticide drift to nontarget areas and in determining the amount of time required before tick control is achieved. Normally, liquid formulations of pesticides provide immediate reduction in tick populations, while granular formulations require a few days before the pesticide is released from the granules into the ticks’ habitat. Liquid formulations of pesticides can be applied to vegetation at various heights to kill questing ticks, whereas granular formulations only affect ticks at ground level. However, granular formulations are generally easier to apply and are less likely to contaminate nontarget areas through pesticide drift. In comparative field studies, it has been shown that both formulations give approximately the same level of control when evaluated over an extended period of 4-6 weeks. Several factors are associated with successful acaricidal tick control, including type of acaricide, ambient temperature, dosage, penetrability of canopy, extent of coverage, susceptibility of the target tick species, tick life stage and physiological condition.
4. Chemical control can be accomplished by conventional ground application, aerial application, or both. The most commonly used pesticides for tick control are diazinon, carbaryl and chlorpyrifos. Most organophosphates and carbamates are less effective at temperatures below 70°F (22°C). These acaricides are mentioned because they are available through the federal stock system and are labeled for tick control. Many other pesticides that provide effective tick control can be purchased from local commercial outlets.

   a. Ground application of diazinon 48% EC (NSN 6840-00-782-3925) against adult deer ticks effectively reduces their density in treated areas. For proper use, see the directions on the EPA-approved label. Diazinon is also labeled for use indoors and around outdoor structures to control the brown dog tick, *Rhipicephalus sanguineus*.

   b. Carbaryl (Sevin™) 5% dust (NSN 6840-01-033-4481) directed against adult deer ticks is effective in reducing population size when applied to the shrub layer. Carbaryl is less effective when temperatures exceed 80°F.

   c. Chlorpyrifos (Dursban™) 41% EC (NSN 6840-00-402-5411) is also effective. It is applied as a spray to roadsides, footpaths, trails, bivouac sites and other infested non-cropland areas. Low underbrush, grassy edges, weeds and ground surfaces should receive special attention. Treated areas should be vacated until the spray has dried. The effective dose for lone star tick (*Amblyomma americanum*) control is 0.25 lbs/acre. This dose should also be effective for deer ticks.

   d. Cyfluthrin, a nonstandard pesticide available as an emulsifiable concentrate, has been shown by various field tests to be highly effective against all stages of lone star and deer ticks when applied to shrub and leaf litter by means of a backpack sprayer. Pyrethroids are more effective at cooler temperatures but begin to lose effectiveness at temperatures above 90°F (33°C).

5. The Damminix™ System (EcoHealth Inc., Boston, MA), while not in the federal supply system, offers an ecologically acceptable means of controlling the deer tick. This system uses cardboard tubes filled with cotton balls impregnated with permethrin. The tubes are placed at 10-yard intervals in a grid pattern throughout and around the area to be protected (e.g., in flower beds, bushes and woodpiles). Foraging mice carry the treated cotton back to their nests to serve as bedding material. The permethrin supposedly disinfests the mice of ticks on a daily basis, while the mice survive to repeat the process. Their ectoparasite load is thereby reduced, as is their potential for infection with *Borrelia burgdorferi*. Two applications are recommended each year: in April, and again in mid-summer. The system is relatively expensive (about $300 per acre per year) and is limited to those rodents that use cotton as a nesting material. This control method was specifically designed for *I. scapularis* but may be effective against other ticks that have cotton-gathering rodents as hosts. One of the main drawbacks of this technique is that deer tick larvae and nymphs feed readily on numerous species of wild mammals and birds, thereby diluting effectiveness.
6. The following considerations apply specifically to lone star and American dog tick (*Dermacentor variabilis*) control using acaricides, but have general application as well. They stem from extensive research on tick control strategies at the USDA Lone Star Tick Laboratory:

   a. The more active ticks are, the better the control achieved with pesticides. As previously stated, tick activity usually stops when temperatures fall below 54°F (13°C).

   b. Localized control efforts provide only localized and temporary relief—they do not significantly reduce the tick population as a whole. Large areas must be treated to achieve effective long-term control. A tick population may take several years to recover after a comprehensive, broad-area control effort.

   c. When only minimal resources are available, treating an area two weeks before it is to be used achieves the maximum control for the effort expended.

D. Deer Exclusion

1. The apparent host specificity of *I. scapularis* adults for deer provides a point of vulnerability that may be exploited to reduce tick population size. Experience has shown that reducing the number of deer will not immediately reduce the number of ticks. Instead, ticks will "double up" on the remaining deer and, to some extent, utilize alternate hosts. Tick densities are not reduced immediately because of the long life cycle of three-host ticks. Following a reduction in deer density, populations of nymphs and adults will take one or two years to fall. Ultimately, eliminating deer in the habitat, either by exclusion or removal, constitutes an effective strategic control measure because deer provide over 90% of adult tick blood meals.

2. A variety of fences have been used to exclude deer, ranging from single electrified wires for areas where the deer population is low, to complex multi-wired electric and nonelectric designs, required in areas where deer pressure is great. A 9-foot (3 m) high, woven-wire, nonelectric fence has been used successfully to exclude deer from recreation areas. Fence selection and design are strongly influenced by location, terrain, vegetation and cost.

3. A 6-wire, vertical, high-tensile, electric anti-deer fence, illustrated in Figure 2, is an effective design appropriate for many situations. Voltage energizers of various capacities, which can electrify short or long runs of fence, are used to charge wires spaced so that deer cannot pass through without contacting them. The hot and ground return wire sequence can be changed with a switching device to provide the most effective shock for snow cover, tall grass, or very dry situations. Vegetation must be controlled with herbicides in a strip 12-18 inches (0.3-0.5 m) wide directly under the fence and by mowing for 5-8 feet (1.5-2.5 m) on the deer side of the fence to minimize voltage drops and to provide the deer with an approach zone. This zone allows deer to perceive the fence as a no-entry barrier that is to be avoided, and encourages a pathway
around the fence rather than through it. Electric deer fences will also work without a mowed
strip when conditions like rough terrain or dense timber make mowing impractical. Contact the
U.S. Army Center for Health Promotion and Preventive Medicine for information on other fence
designs, material suppliers and costs.

4. The limitations of an electric fence system are the initial high cost, the
requirements for regular maintenance and vegetation control, and the cost of battery replacement
and/or AC current. However, fencing may be appropriate around residences and in selected
recreational areas.

5. Limiting the size of deer herds roaming in game management areas or range
areas will ultimately reduce the deer pressure on adjoining training and recreational areas.
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### APPENDIX A - TICK SURVEILLANCE METHODOLOGY

<table>
<thead>
<tr>
<th>Method</th>
<th>Ixodes scapularis</th>
<th>Amblyomma americanum</th>
<th>Dermacentor variabilis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat Survey</td>
<td>2,4,7 wood, grass, depends on mammal activity</td>
<td>2,4,7 deer bedding, wooded areas</td>
<td>2,4,7 edge habitat, animal trails &amp; old fields</td>
</tr>
<tr>
<td>Tick Drags</td>
<td>2,3,4,7 immatures spring, adults in fall</td>
<td>2,3,4,7 immatures &amp; adults</td>
<td>2,3,4,7 adults along animal trails</td>
</tr>
<tr>
<td>Deer Checks</td>
<td>2,4,5,8 late fall, winter</td>
<td>7 - better determined by other methods</td>
<td>NA</td>
</tr>
<tr>
<td>Dog Checks</td>
<td>2,3,4,5,6,7 immatures in spring, adults in fall/winter</td>
<td>NA</td>
<td>2,4,7 adults</td>
</tr>
<tr>
<td>CO₂ Traps</td>
<td>2,3,4,6,7,8 overnight, hit or miss, ticks slow moving</td>
<td>2,3,4,5,6,7 spring, summer - 2 hr. in morning</td>
<td>2,3,4,7,8 summer for adults, few nymphs, patchy</td>
</tr>
<tr>
<td>Tick Walks (white cotton clothing)</td>
<td>2,3,4,5,6,7,8 spring, summer &amp; fall</td>
<td>2,3,4,5,6,7 spring &amp; summer</td>
<td>2,3,4,5,6,7,8 summer</td>
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<tr>
<td>Small Mammal Check</td>
<td>4,5,6,8 spring/summer Peromyscus leucopus</td>
<td>NA</td>
<td>4,5,6,8 spring &amp; summer</td>
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<td>Method</td>
<td><em>Ixodes scapularis</em></td>
<td><em>Amblyomma americanum</em></td>
<td><em>Dermacentor variabilis</em></td>
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<td>--------------------------</td>
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<tr>
<td>Tick Testing</td>
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<td>2,8,9</td>
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<td></td>
<td>Lyme Disease</td>
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<tr>
<td></td>
<td>Babesiosis</td>
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<td>expect 1 case per 30,000+</td>
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<tr>
<td></td>
<td>Ehrlichiosis</td>
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<tr>
<td>Deer Serology</td>
<td>8,9</td>
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</tbody>
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**Key to numerical codes:**

1. Determine disease presence in amplifying host.
2. Useful in determining need for control.
3. Useful in control evaluation.
4. Indicator of tick presence.
5. Provides information pertinent to population dynamics.
6. Provides quantitative/density information.
7. Technique useful in nuisance assessments.
9. Indicates pathogen presence.
1. GENERAL EQUIPMENT

* Insulated shipping boxes for shipping serum samples (approx. 1 cu. ft. size)

* White cotton coveralls or white cotton pants and shirt (NOT treated with repellent)

* White socks NOT treated with repellent

* Boots, preferably without eyelets, for protection during mammal trapping

* Flagging (surveyor’s tape)

* Wide (6 cm) masking tape for sealing eyelets, boot tops, shirt openings, and for removing immature ticks collected during tick walks

* Mosquito head nets

* Coveralls

* Data forms (small mammal sampling form, deer sampling form, tick walk form. See Appendix J)

* Refrigerator foam packs for shipping serum or tick samples

* Dry ice

* Rubber gloves (e.g., disposable surgical) for handling small mammals and deer

* Pencils and permanent marker pens

2. TICK WALK SURVEY

* High top shoes (boots), bloused pants

* White drag cloth (1 x 1/2 m, or 1 x 1 m) mounted on dowel

3. SMALL MAMMAL SURVEY

* Folding aluminum Sherman box traps, approx. 3.5 x 3.5 x 9 in. (9 x 9 x 22.5 cm) - 60 to
300 traps for trap lines plus 5 extra for replacement of damaged, lost, or stolen traps

* Cotton balls (nesting material for traps)

* Peanut butter/oatmeal bait recipe: Place approx. 4 cups of dry oatmeal (preferably the long-cooking style) in a large mixing container such as a 5-pound coffee can. Add approximately 1 tablespoon of peanut butter per cup of oatmeal and mix well, using your hand to knead the mixture. Continue kneading until the peanut butter is evenly distributed and the mixture is crumbly and does not clump together. Approximately 1 tablespoon of this mixture is used per trap.

* Felt-tipped marking pens for traps

* Cloth or leather gloves (e.g., gardening gloves) for handling traps

* Large (approx. 30-gal.) plastic bags for carrying traps/animals to lab

* 10-ml vial of 100 mg/ml or 50-ml vial of 10 mg/ml Ketamine hydrochloride injectable for small mammal anesthesia

* Tuberculin syringes with needles (1-cc syringes with approx. 26-gauge x 1/2-in. needles) for small mammal anesthesia

* 30-cm ruler

* 100-g Pesola spring scale for weighing small mammals

* Materials listed under BLOOD/SERUM COLLECTING EQUIPMENT

* Materials listed under TICK COLLECTING EQUIPMENT

* Small mammal blood collection protocols (TIM 40)

4. DEER SURVEY MATERIALS

* Rubber gloves (e.g., disposable surgical) for handling small mammals and deer

* 5-cc syringes with 19 or 21-gauge x 1.5-in. needles for deer blood collection

* 5- to 10-ml glass screw-cap centrifuge tubes or 7-ml Vacutainer tubes for all blood samples
* Materials listed under BLOOD/SERUM COLLECTION EQUIPMENT

* Materials listed under TICK COLLECTION EQUIPMENT

** Deer blood collection kits for hunters, which include:
  - Twirlpak bag
  - Disposable polypropylene transfer pipette
  - Labeled 5- to 10-ml glass, screw-cap centrifuge tube or 7-ml Vacutainer tubes
  - Vacutainer blood collection tube
  - Protocol for Blood Collections from Deer, Deer Sampling Survey Form, and Lyme Disease Fact Sheet
  - Small pencil
  - Disposable gloves

5. TICK COLLECTION EQUIPMENT

* Squeeze bottle for water

* Squeeze bottle for 70% alcohol

* Cotton dressings for use with alcohol to surface-sterilize equipment, etc.

* Fine paint brush for transferring ticks

* Needle-nose forceps, Swedish or Dumont forceps for small mammal tick collection

* White enameled pan or white plastic cloth for processing small mammals

* Labeled snap-cap or screw-cap plastic vials (for tick samples) with a filter paper strip insert for moisture

* Scalpel blade and handle for aid in dislodging ticks from deer

* Medium forceps for tick collection from deer

6. BLOOD/SERUM COLLECTING EQUIPMENT

* 1-cc syringes with approx. 23- to 25-gauge x 1/2-in. needles for small mammal cardiac puncture, if necessary

* 100-count micro hematocrit tubes for retro-orbital blood sampling of small mammals
* 5- to 10-ml glass or plastic, capped centrifuge tubes or 7-ml Vacutainer tubes for all blood samples

* 2-ml Wheaton or Sarstedth vials for all serum samples

* Glass Pasteur pipettes for serum transfers

* Pipette bulbs

* Plastic Twirlpak disposable bags for carcasses and medical waste

* White labels for labeling sample vials

* Disposable wood applicators, 6 x 1/2-in. (swab sticks, minus cotton) for clot removal from coagulated blood

* Scalpel blade and handle for performing venous cut-down
APPENDIX C - PROTOCOL FOR BLOOD COLLECTIONS FROM DEER

I. Pre-arrangements

A. Hunters must first be notified of the need to collect blood specimens and ticks from their deer. This notification is coordinated through the installation wildlife biologist, game warden, safety officer, or other personnel responsible for the installation hunting program. These arrangements are best made several months before hunting season to allow incorporation into the hunting program.

B. Several subject areas can be covered when the hunter is contacted.

   1. Lyme disease information, including personal protective measures, should be provided to the hunter through pamphlets or a briefing.

   2. Options for collecting blood specimens can also be communicated to the hunter, who may either obtain the blood sample from the deer himself or bring the undressed deer to the check station.

   3. Hunters should also be asked to allow a brief period of time (15 min.) at check-out for tick collection by investigators/survey personnel.

C. If hunters will be responsible for obtaining blood samples, prepare or arrange for an adequate supply of blood collection kits. Each kit should contain a collection tube (non-heparinized glass or plastic, stoppered tube, 7-ml or greater volume), disposable plastic pipette (eyedropper), pencil, deer data record form, plastic disposable glove or other hand covering, tissue paper, and an information sheet on Lyme disease for hunters. Package the kit in a resealable plastic bag. A copy of the deer data record form should be provided.

D. To optimize collection of specimens, ask personnel responsible for the hunting program to provide the typical time period for hunter check-in and check-out. Schedule tick collection times based on this information.

II. Blood Collection by the Hunter. This procedure should be used when a high level of hunter cooperation is expected and there are enough blood collection kits on hand to distribute to each hunter or hunting party.

A. Distribute kits to hunters. Instruct hunters in taking a blood sample (see Section B, below) and providing the deer carcass for a 15-minute examination at the check-out point upon returning from the field.
B. Take a cardiac blood sample from each deer immediately following the kill. Blood should be taken directly from the heart if possible. Blood can be obtained by making a small cut (1/4 inch or 6mm) in the heart with a hunting knife and using the pipette to remove the sample. Extract as much blood as possible. If blood cannot be obtained this way, collect pooled blood from the chest cavity. As a last resort, the hunter can bring the heart with the deer to the check-out station.

C. The hunter must fill out the top part of the deer data record sheet and mark the blood tube with his/her name so that it can be properly identified. All information provided by the hunter remains confidential.

D. The blood sample and data sheet will be turned in at check-out to the survey personnel, who will then record the proper identification number on the tube (see section III. C. below).

E. Collect all unused kits at check-out.

III. Blood Collection at Check-out Station.

A. If blood collections cannot be made in the field, arrange to have all hunters bring their intact deer to the check-out station. This will likely require the survey personnel to perform or assist in field dressing of the deer.

B. Collect blood using either the procedures described in paragraph II. A. above or a needle (1 1/2" or greater length, 19-gauge or larger bore) and syringe (5-ml or greater volume). Syringe-drawn specimens are obtained by laying the deer on its right side and inserting the needle through the left flank, piercing between the ribs about two to four inches (5-10cm) behind the left shoulder.

C. Print the sample number on the collection tube and the survey form. This number will consist of the year, month, day, ARLOC/UIC number for the installation, and sequence number of deer processed that day. Example: a sample taken on 12 September 1997 for the 10th deer sampled that day would be 970912; 63117 is the UIC for the Navy Environmental Preventive Medicine Unit, Norfolk, and 10 is the tenth deer taken that day; therefore, the complete number would be recorded as 970912-63117-10. The ARLOC/UIC code number for the installation will be different depending on what branch of Service is doing the sampling.

D. If possible, obtain at least 50 samples. This is the minimum number of samples needed to detect a true prevalence rate of at least 5% (at a 95% probability level).

E. Allow the blood samples to remain at room temperature for at least two hours in order to clot. Remove each clot with a wooden applicator swab stick by spinning the clot around the stick. Dispose of the clot, and retain the remaining serum sample. Use a Pasteur pipette to draw
off the serum and transfer it to a clean vial (1-ml or larger volume Wheaton or Sarstedth vial).

F. If a centrifuge is available, spin the original samples (2000 x g, 5 minutes) after "rimming" each clot away from the tube wall with a wooden applicator. Pipette the serum to a vial, as above, and label with the sample number. Freeze the serum samples, and transport them frozen if possible. Store the collected serum at -5°F (-20°C) or colder for serological analysis.

G. Record age (fawn, yearling, adult), sex, time of day deer was shot, time processed at check-in station, hunting area or location (e.g., deer stand number), and deer registration number on the deer survey form. Note any other special events or observations on the form as well.
APPENDIX D - PROTOCOL FOR ESTABLISHING SEROLOGY EVALUATIONS FOR DOGS

Purpose and Significance

Efforts to mitigate the impact of Lyme disease in the northeastern United States are currently limited by our inability to track the early spread of deer ticks into new areas and, subsequently, to educate residents and physicians about the increased risk of tick bites. Dogs suffer from Lyme disease (canine borreliosis) and, because of a generally higher exposure to ticks in the environment, may acquire the disease earlier than humans in the same area. Examination of canine blood samples is an important surveillance tool for detecting the presence of the Lyme disease spirochete. Positive results of canine serology tests denote high local risk of infection in dogs, which are typically asymptomatic, and in humans. Such information can contribute to our understanding of the epidemiology of Lyme disease and its spread to new areas, and should facilitate efforts to inform the public before human involvement becomes significant.

A. Methods

Obtain at least 15-30 blood samples from different dogs, up to a maximum of 100. Serum should be submitted from animals that are most likely to have been exposed to tick vectors. Outdoor dogs, hunting dogs, and dogs known to have had tick infestations are good candidates. If there is an installation hunt club, consider briefing the club about the survey and obtaining samples from their hunting dogs. Dogs to be tested should be over six months of age and selected at random; that is, no preference should be given to dogs with symptoms suggesting canine borreliosis. Blood can be collected at the same time it is being drawn for heartworm tests. However, such samples would not be random because dogs tested for heartworm represent a subset of the canine population that receives superior veterinary care. With a syringe, collect 3-4 cc of blood, place it in a "red cap" tube (no additives), and centrifuge for 15 minutes at medium-high speed. Serum should be drawn off with a clean pipette and placed in a sterile, labeled tube. The label should include location, name, and date. The tube should be capped and frozen until sent to the laboratory. If a centrifuge is unavailable, refrigerate the whole blood until it can be shipped to the laboratory. NOTE: Uncentrifuged whole blood samples should not be held any longer than 2 days before being forwarded.

B. Include a sheet with the sample, listing the following information:

1. Identification number or name of each sample for individual test results.
2. Date the sample was collected.
3. Age and sex of the dog.
4. Street address and town where the dog lives.
5. If the dog has a history of borreliosis, describe it and give symptoms.
6. State whether the dog been vaccinated for leptospirosis.
APPENDIX E - KEYS TO THE GENERA OF IXODIDAE AND ARGASIDAE
IN NORTH AMERICA

Ixodidae
(Adults)

Armed Forces Pest Management Board
Walter Reed Army Medical Center

1. Eyes present ............................................................. 4
   Eyes absent .............................................................. 2

2. Anal groove extending anterior to anus ................................. Ixodes
   Anal groove not extending anterior to anus ........................... 3

3. Palps short; palpal segment II with prominent lateral extension ...... Haemaphysalis
   Palps elongate; palpal segment II without lateral extension .......... Aponomma

4. Palps very short, shorter than chelicerae or hypostome .................. Boophilus
   Palps as long as or longer than chelicerae or hypostome .............. 5

5. Goblet cells very large, usually about 7 in number; festoons 7 ........ Anocentor
   Goblet cells smaller and more numerous; festoons 11 ...................... 6

6. Palpi long, segment II especially so .................................. Amblyomma
   Palpi short .................................................................... 7

7. Basis capituli rectangular dorsally; scutum usually ornate .......... Dermacentor
   Basis capituli hexagonal dorsally; scutum inornate ...................... Rhipicephalus
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Species</th>
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<tbody>
<tr>
<td>1.</td>
<td>Eyes present</td>
<td></td>
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<tr>
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<td>Eyes absent</td>
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</tr>
<tr>
<td>2.</td>
<td>Anal groove extending anterior to anus</td>
<td><em>Ixodes</em></td>
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<tr>
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<td>Anal groove not extending anterior to anus</td>
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</tr>
<tr>
<td>3.</td>
<td>Palps short; palpal segment II with prominent lateral extension</td>
<td><em>Haemaphysalis</em></td>
</tr>
<tr>
<td></td>
<td>Palps elongate; palpal segment II without lateral extension</td>
<td><em>Aponomma</em></td>
</tr>
<tr>
<td>4.</td>
<td>Palps very short, shorter than chelicerae or hypostome</td>
<td><em>Boophilus</em></td>
</tr>
<tr>
<td></td>
<td>Palps as long as or longer than chelicerae or hypostome</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Goblet cells very large, usually 3-4 in number; festoons 7</td>
<td><em>Anocentor</em></td>
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<tr>
<td></td>
<td>Goblet cells much smaller and more numerous; festoons 9-11</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Scutum broadly cordiform, generally wider than long</td>
<td><em>Amblyomma</em></td>
</tr>
<tr>
<td></td>
<td>Scutum more or less trapezoidal, as long as or longer than wide</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Anal groove with distinct posteromedian extension; palpal segment I not</td>
<td><em>Rhipicephalus</em></td>
</tr>
<tr>
<td></td>
<td>visible dorsally; festoons 9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anal groove embracing posterior margin of anus but without posteromedian</td>
<td><em>Dermacentor</em></td>
</tr>
<tr>
<td></td>
<td>extension; palpal segment I inconspicuous but visible dorsally; festoons 11</td>
<td></td>
</tr>
</tbody>
</table>

Armed Forces Pest Management Board
Walter Reed Army Medical Center
Argasidae
(Adults and Nymphs)

J.E. Keirans (unpublished, 1986)
Acarology Summer Program
The Ohio State University

1. With a definite sutural line separating the dorsal and ventral surfaces .............. Argas
   Lacking a definite sutural line .............................................................................. 2

2. Nymphs with integument beset with spines, hypostome well developed; adults with
   integument granular, hypostome vestigial ......................................................... Otobius
   Nymphal and adult integument lacking spines; hypostome of adult various in form but not
   vestigial .................................................................................................................. 3

3. Dorsum of adult and nymph with a smooth raised area or false scutum; palpal segment I with
   a large flange partially obscuring the hypostome .............................................. Nothoaspis
   Dorsum of adult lacking a false scutum; palpal segment I without a flange ............. 4

4. Hypostome broad at the base and scoop-like (associated with bats) ................. Antricola
   Hypostome of various forms but with denticles and never scoop-like (found on various
   animals including bats) ......................................................................................... Ornithodoros
## APPENDIX F - DEPARTMENT OF DEFENSE AND OTHER FEDERAL AGENCIES
**PROVIDING LYME DISEASE TRAINING AND INFORMATION**

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<thead>
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<tr>
<td><strong>USACHPPM</strong></td>
<td><strong>USACHPPM - Europe</strong></td>
</tr>
<tr>
<td>Aberdeen Proving Ground, MD</td>
<td>APO AE 09180-3619</td>
</tr>
<tr>
<td>21010-5422</td>
<td>011-49-6371-86-8540</td>
</tr>
<tr>
<td>(410) 671-3613</td>
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<tr>
<td>DSN 584-3613</td>
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<tr>
<td>Fort Meade, MD 20755-5225</td>
<td>Fort McPherson, GA 30330-5000</td>
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<tr>
<td>(301) 677-5281/6502</td>
<td>(404) 752-2564/3984</td>
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<td>Fax -7132</td>
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<tr>
<td><strong>U. S. Army Medical Center and School</strong></td>
<td><strong>Navy Public Health Command</strong></td>
</tr>
<tr>
<td>Fort Sam Houston, TX 78234-6142</td>
<td>2510 Walmer Ave.</td>
</tr>
<tr>
<td>(210) 221-4278/5270</td>
<td>Norfolk, VA 23513-2617</td>
</tr>
<tr>
<td>Fax -5948</td>
<td>(757) 363-5593</td>
</tr>
<tr>
<td>DSN 471-4278/5270</td>
<td>Fax 444-1345</td>
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<tr>
<td>Naval Station</td>
<td>Naval Station, Box 368143</td>
</tr>
<tr>
<td>Norfolk, VA 23571-6288</td>
<td>San Diego, CA 92136-5199</td>
</tr>
<tr>
<td>(804) 444-7671</td>
<td>(619) 556-7077</td>
</tr>
<tr>
<td>Fax -1191</td>
<td>Fax -7071</td>
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<td>DSN 564-7671</td>
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<tr>
<td>NAS, Box 43</td>
<td>19950 7th Ave., N.E., Suite 201</td>
</tr>
<tr>
<td>Jacksonville, FL 32212-0043</td>
<td>Poulsbo, WA 98370-7405</td>
</tr>
<tr>
<td>(904) 542-2424</td>
<td>(360) 315-4476/4450</td>
</tr>
<tr>
<td>Fax -4324</td>
<td>Fax -4455</td>
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<tr>
<td>Box 112</td>
<td>FPO AE 09623-2760</td>
</tr>
<tr>
<td>Pearl Harbor, HI 96860-5040</td>
<td>011-39-95-56-3982/4101</td>
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<td>(808) 471-9505</td>
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APPENDIX G - DEPARTMENT OF DEFENSE AND OTHER FEDERAL AGENCIES PROVIDING LYME DISEASE LABORATORY SUPPORT

USACHPPM
Aberdeen Proving Ground, MD 21010-5422
Services provided: 1, 2

USACHPPM - North
Fort Meade, MD 20755-5225
Services provided: 1, 2

USACHPPM - South
Fort McPherson, GA 30330-5000
Services provided: 1, 2

U. S. Army Regional Veterinary Lab
Building P-2490
Fort Meade, MD 20755-5235
DSN 923-2930; CM (301) 677-2930
Services provided: 3

USACHPPM - Europe
APO AE 09180-3619
Services provided: 1

NEPMU-2
Naval Station
Norfolk, VA 23511-6288
Services provided: 1

NEPMU-5
Naval Station, Box 368143
San Diego, CA 92136-5199
Services provided: 1

NEPMU-6
Pearl Harbor, HI 96860-5040
Services provided: 1

NEPMU-7
FPO AE 09623-2760
Services provided: 1

Centers for Disease Control and Prevention
Division of Vector-borne Infectious Diseases
Fort Collins, CO 80522
Services provided: 1, 2, 3, 4

KEY:
1. Tick identifications
2. Detection of spirochetes within vectors
3. Deer and canine serologies
4. Human serologies (performed only when specimen is submitted through a state health department)
APPENDIX H - REFERENCES


APPENDIX I - TICK-BORNE DISEASE FACT SHEETS
Protect Yourself from Tick-Borne Diseases

Ticks can carry and transmit (vector) a wide variety of disease-causing organisms (pathogens). Different kinds (species) of ticks generally transmit different pathogens, that is, they are considered vectors for specific disease organisms. Some ticks can be vectors for more than one kind of pathogen.

Not all ticks are infected, so a tick bite does not necessarily mean you will get a disease. In addition, even if a tick is infected, it must be attached to your skin for at least several hours before it can successfully transmit the pathogens to you. Therefore, the sooner you remove attached ticks, the safer you will be.

Tick Species and Life Stages Most Likely to Transmit Pathogens to Humans in the U.S.

<table>
<thead>
<tr>
<th>Tick Species</th>
<th>Disease</th>
<th>Pathogen</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ixodes scapularis</em> (black-legged tick, also known as deer tick)</td>
<td>Lyme disease</td>
<td><em>Borrelia burgdorferi</em></td>
</tr>
<tr>
<td></td>
<td>Human granulocytic ehrlichiosis</td>
<td><em>Ehrlichia sp.</em></td>
</tr>
<tr>
<td></td>
<td>Babesiosis</td>
<td><em>Babesia microti</em></td>
</tr>
<tr>
<td>Female: Adults</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male: Nymph</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Amblyomma americanum</em> (Lone Star tick)</td>
<td>Human monocytic ehrlichiosis</td>
<td><em>Ehrlichia chaffeensis</em></td>
</tr>
<tr>
<td>Female: Adults</td>
<td></td>
<td></td>
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<tr>
<td>Male: Nymph</td>
<td>Lyme disease-like illness</td>
<td><em>Borrelia sp.</em></td>
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<tr>
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</tr>
<tr>
<td><em>Dermacentor variabilis</em> (American dog tick)</td>
<td>Rocky Mountain spotted fever</td>
<td><em>Rickettsia rickettsii</em></td>
</tr>
<tr>
<td>Female: Adults</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male: Nymph</td>
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</table>

There are additional tick species that bite humans in limited areas of the United States. They include: *Ixodes pacificus* (western black-legged tick) which looks identical to *Ixodes scapularis* and transmits the same or closely related pathogens as that tick species, but is present only in the Pacific Coast states; and *Dermacentor andersoni* (Rocky Mountain wood tick), which looks very similar to *Dermacentor variabilis*, and transmits RMSF, but only in the Rocky Mountain states.
Ticks go through several stages in their life cycle: egg, larva, nymph, and adult (male and female at this stage). For all tick species, the larva is very tiny (a mere speck), the nymph is a little larger (but still very small, about the size of a pin head), and the adults are larger and easy to see. Larval ticks rarely transmit pathogens to man, but both nymphs and adults may do so. Nymphs are of greatest concern, owing to their small size which makes them easy to overlook.

A tick needs a blood meal from a host (mammal, bird, reptile, or human) in order to molt (progress to the next stage of it's life cycle), and to reproduce (mate and lay eggs) as adults. This feeding process continues for several days to a week until the tick is fully engorged with blood. It then releases it's hold from the host, drops off, and subsequently molts or lays eggs. If the tick is infected with pathogens, it can transmit the infection to the host (this could be you!) during the feeding process.

**DO THIS:**

- Wear the proper clothing:
  - Long pants tucked into boots or socks;
  - Long sleeves;
  - Shirt tucked into pants;
  - Light-colored clothing makes it easier to spot ticks.

- Use these safe and effective insect repellents:
  - Treat clothing with permethrin repellent. When ticks crawl on the fabric, they absorb a tiny amount of permethrin, making them too sick to bite you. Follow application directions on the repellent label. Order aerosol (NSN 6840-01-278-1336), or impregnation kit (NSN 6840-01-345-0237, for military uniforms only).
  - Apply deet repellent to skin that is not covered by clothing. Follow application directions on the label. Order NSN 6840-01-284-3982.

- Check yourself for ticks routinely:
  - Use the buddy system;
  - When you go indoors, remove your clothes and shower, checking your skin carefully;
  - You can place your clothes in a hot dryer for 20-30 minutes to ensure that any ticks you failed to notice will be killed;
  - Check children and pets carefully.

- Remove attached ticks immediately:
  - Grasp the tick's mouthparts as close to the skin as possible with fine-tipped tweezers; gently and steadily pull straight back, until the barbed mouthparts can be eased out of the skin. **BE PATIENT.**
  - DO NOT squeeze the body of the tick as this may force infective fluid into you.
  - DO NOT apply any substance, including petroleum jelly, finger nail polish, finger nail polish remover, repellents, pesticides, or a lighted match to the tick while it is attached. These materials are either ineffective, or worse, might agitate the tick, causing it to regurgitate infective fluid into the bite site.
  - Wash the bite site with soap and water, and apply an antiseptic.
  - Save the tick for future identification should you develop disease symptoms. Preserve it by placing it in some alcohol, or by keeping it in the freezer. Discard after one month as all known tick-borne diseases will generally display symptoms within this time period.
  - If you develop flu-like illness or otherwise feel sick following a tick bite, seek medical attention immediately.

U.S. Army Center for Health Promotion and Preventive Medicine
ATTN: Entomological Sciences Program
Aberdeen Proving Ground, Maryland 21010-5422
TICK REMOVAL

1. REMOVE TICKS PROMPTLY.

   a. If a tick is found attached to the body (Figure 1), seek assistance from medical authorities for proper removal, or follow these guidelines:

      (1) **Grasp the tick’s mouthparts** against the skin, using pointed tweezers (Figure 2).

      (2) **Pull back slowly and steadily** with gentle force.

      (a) Pull in the reverse of the direction in which the mouthparts are inserted, as you would for a splinter.

      (b) **BE PATIENT** -- The long, central mouthpart (called the hypostome) is inserted in the skin. It is covered with sharp barbs, sometimes making removal difficult and time consuming (Figure 3, inset).

      (c) Most hard ticks secrete a cement-like substance during feeding. This material helps secure their mouthparts firmly in the flesh and adds to the difficulty of removal.

      (d) It is important to continue to pull steadily until the tick can be eased out of the skin (Figure 3).

      (e) **DO NOT** pull back sharply, as this may tear the mouthparts from the body of the tick, leaving them embedded in the skin. If this happens, do not panic. Embedded mouthparts are comparable to having a splinter in your skin. However, to prevent the chance of secondary infection, it is best to remove them. Seek medical assistance if necessary.

      (f) **DO NOT** squeeze or crush the body of the tick because this may force infective body fluids through the mouthparts and into the wound.

      (g) **DO NOT** apply substances such as petroleum jelly, fingernail polish, fingernail polish remover, repellents, pesticides, or a lighted match to the tick while it is attached. These materials are either ineffective, or worse, might agitate the tick and cause it to salivate or regurgitate infective fluid into the wound site.

      (3) If tweezers are not available, grasp the tick’s mouthparts between your fingernails, and remove the tick carefully by hand. Be sure to wash your hands and under your fingernails, to prevent possible contamination by infective material from the tick.

2. Following removal of the tick, **wash the wound** (and your hands) with soap and water and apply an antiseptic.

3. Save the tick in a jar, vial, small plastic bag, or other container for identification should you later develop disease symptoms. Preserve the tick by either adding some alcohol to the jar or by keeping it in the freezer. Storing a tick in water will not preserve it. Identification of the tick will help the physician’s diagnosis and treatment, since many tick-borne diseases are transmitted only by certain species.

4. Discard the tick after one month; all known tick-borne diseases will generally display symptoms within this time period.

USACHPPM

U.S. Army Center for Health Promotion and Preventive Medicine
ATTN: Entomological Sciences Program
Aberdeen Proving Ground, Maryland 21010-5422
FACT SHEET
LYME DISEASE

WHAT IS LYME DISEASE (LD)?

Lyme disease is an infectious disease that often begins with a characteristic rash, and which can later involve the joints, nervous system and/or heart. It is caused by a spiral-shaped bacterium called a spirochete that is transmitted to humans by the bite of an infected tick.

WHERE IS LD FOUND?

In 1975, an investigation of geographic clustering of children with arthritis in Lyme, Connecticut led to the description of this newly recognized disease. It is now apparent that LD occurs over wide areas of the United States. These areas correspond to the distribution of the known tick species that carry the disease. Currently, the major affected areas are the Northeast from Massachusetts to Maryland, the Midwest around Wisconsin, and the West around California. Cases have been reported in most other states, however, as well as in many other parts of the world, particularly Europe and Asia.

HOW IS LD TRANSMITTED?

In the East and Midwest, the "black-legged tick" (Ixodes scapularis, also known as the "deer tick" or "bear tick"), and in the West, the "western black-legged tick" (Ixodes pacificus), are the known tick transmitters (or vectors) of the disease. In other cases, the tick is very small (i.e., smaller than the well-known American dog tick, Dermacentor variabilis), or the Lone Star tick, Amblyomma americanum, and the immature stages are no larger than the period on a printed page. The ticks cling to vegetation and are most numerous in woods and leaf litter, high grass, weeds and brush. The tick's two year life cycle requires that the tick feed (take a blood meal) on three separate hosts. These hosts include a variety of animals, including birds, but white-footed mice and deer are preferred. The spirochete that causes LD, Borrelia burgdorferi, is acquired by juvenile ticks (larvae) that feed on an infected animal, usually a mouse. The next juvenile stage of the tick (nymph), attaches to vegetation and is transferred by direct contact to the skin of a passing animal or human. The bite of the infected nymphal tick can then transmit the infectious organism to the new host. Thus, the greatest chance of becoming infected by the bite of the tick occurs during May through July, the period of greatest nymphal tick activity in most areas. The adult tick (primarily the female) feeds mainly on deer but may also become attached to, and infect humans. Adults are active during the fall and early spring. It is important to remember that not all ticks carry Lyme disease. Thus, a tick bite does not necessarily mean that disease will follow, and prompt removal of a tick will lessen any chance of disease transmission.

WHAT ARE THE SYMPTOMS?

Early -- The first symptom of LD is usually a skin rash, called erythema migrans (EM), that occurs at the site of the tick bite. The actual tick may go unrecognized. The rash, which begins 3 days to one month after the tick bite, begins in a small red area which gradually enlarges, often with partial clearing in the center of the lesion so that it resembles a donut or bulls-eye. The skin lesion is occasionally described as burning or itching. Up to 40% of people with LD may not have the early skin rash, and symptoms may appear only in the later stages of the disease. Other common early signs of LD - with or without the rash - are flu-like symptoms such as fever, headache, stiff neck, sore and aching muscles and joints, fatigue, sore throat, and swollen glands. The eyes may sometimes be affected (conjunctivitis). If not treated, these symptoms may disappear on their own over a period of weeks; however, the rash may recur as multiple secondary lesions in about 50% of untreated people, and more serious problems may follow later. If treated with appropriate antibiotics, the skin rash goes away within days, and complications may be avoided.

Late -- Later symptoms of the disease can include complications of the joints, the nervous system, and the heart. They typically appear weeks to months after the initial symptoms. Symptoms in the joints occur in up to 60% of untreated persons. This is an arthritis affecting the large joints, primarily the knee, elbow and wrist. Pain, swelling or stiffness can move from joint-to-joint, and can become chronic. Neurologic complications occur in 10-20% of infected persons. The most common symptoms include severe headache and stiff neck (aseptic meningitis), facial paralysis (Bell's palsy or other cranial nerve palsies), and weakness and/or pain in the chest or extremities (radiculoneuritis). These symptoms can persist for weeks, often fluctuate in severity, and may respond to intravenous antibiotics.
Heart symptoms occur in 6-10% of infected persons. The electrical conduction in the heart may be affected (heart block), and an inflammation of the heart muscle (myocarditis), may occur.

**HOW IS LD DIAGNOSED?**

Diagnosis is based primarily on recognition of the typical symptoms of LD such as the characteristic skin rash occurring in a person who lives in or has visited one of the areas mentioned earlier. **PROMPT TREATMENT OF EARLY SYMPTOMS MAY PREVENT LATER AND MORE SERIOUS PROBLEMS.**

Atypical cases, or cases presenting with only later stage complications, are difficult to diagnose. In these persons, a blood test looking for antibody to the causative bacteria is often helpful. It should be noted that early in the disease, this blood test can be negative even though disease is present; only with later disease does the test become reliably positive.

**WHAT IS THE TREATMENT?**

Oral antibiotic treatment is beneficial early in the illness and often prevents late complications. Amoxicillin and doxycycline are the most effective drugs. In children, amoxicillin is preferred (erythromycin may be substituted, although it may be less effective). For late stage complications, high-dose intravenous penicillin or ceftriaxone is often effective.

**HOW CAN LD BE PREVENTED?**

Knowledge of where these ticks are found, avoidance of such areas, and, if bitten, prompt removal of the tick, are the primary preventive measures. Persons living in areas where ticks are prevalent, particularly if the known tick vector species is present, should be aware of the following preventive measures:

- If you walk in tick habitat (tall grass and weeds, scruffy areas, woods and leaf litter), wear a long-sleeved shirt, long pants, and high socks (with pants tucked tightly into the socks). Light colors will help with recognition of the tick on clothing.
- Use a repellent containing permethrin on your clothing and a repellent containing deet (N,N-diethyltoluamide) on your exposed skin.
- Conduct daily “tick checks”. The ticks are most often found on the thigh, groin, arms, underarms, and legs, and immature ticks are very small. Look for new “freckles”.
- To remove a tick, use tweezers to firmly grip the tick’s mouthparts as close to the skin as possible, and pull back slowly and steadily. Be patient - the tick’s central mouthpart called the hypostome is covered with sharp barbs. Sometimes making removal difficult. Don’t pull back sharply, as this may tear the mouthparts from the body of the tick, leaving them embedded in the skin. If the mouthparts do break off, don’t panic - the mouthparts alone cannot transmit LD because the infective body of the tick is no longer attached. However, to prevent secondary infection, remove the mouthparts as you would a splinter. DON’T SQUEEZE THE BODY OF THE TICK, as this may force infective fluid into the wound site.
- After removal, wash the wound and apply an antiseptic. **SAVE THE TICK in the event that symptoms arise, because identification of the tick may facilitate the physician’s diagnosis and treatment. You can preserve the tick by placing it in a jar with a little alcohol, or by keeping the jar in your freezer.**
- 

Be aware of the symptoms of Lyme disease. IF YOU HAVE BEEN IN AN AREA WHERE THE TICK IS FOUND AND YOU DEVELOP SUCH SYMPTOMS, PARTICULARLY THE SKIN RASH AND/OR ‘FLU’ SYMPTOMS DURING THE PERIOD FROM MAY THROUGHOUT EARLY FALL, YOU SHOULD PROMPTLY SEE A PHYSICIAN FOR EVALUATION AND TREATMENT.

Acknowledgement: This Fact Sheet is taken, in part, from a Public Health Fact Sheet produced by the Massachusetts Department of Public Health.

Commander
U.S. Army Center for Health Promotion and Preventive Medicine
ATTN: Entomological Sciences Program
Aberdeen Proving Ground, Maryland 21010-5422
DSN 584-3613; Commercial (410)671-3613
FACT SHEET - MOSQUITO and TICK REPELLENTS

* DEET (N,N-Diethyl-m-toluamide) containing repellents offer good protection from mosquitoes, and are formulated for application to exposed skin.

* Permethrin containing repellents offer excellent protection from ticks, and are formulated for application to clothing.

* DEET will also offer protection from ticks, keeping them from attaching to treated skin. However, ticks generally do not attach in exposed areas, the only areas DEET may be applied to.

* Permethrin, on the other hand, will also offer protection from mosquitoes, but may not be applied to exposed skin where mosquitoes bite. It is useful in treating bed netting.

* Combined use of DEET on exposed skin for mosquito repellency and Permethrin on clothing for tick repellency offers maximum protection from both pests. Always read and follow the label before using any compound.

* Do not use tick and flea collars. A toxic reaction can result. Humans have sweat glands in their skin that serve as an avenue for chemical absorption. Dogs on the other hand, respire by panting, lacking sweat glands. In addition, pets have a thicker hair barrier than most humans to protect them from direct contact with the collars.

* Various lotion products have acclaim as offering protection from mosquitoes. Professional literature both supports and refutes benefits from lotions. However, there is a consensus that mineral oil, a component of many lotions, does substantially reduce mosquito bites on treated skin.

* Tests have shown that DEET products containing a high concentration of DEET do not offer greater protection than those products containing 30-50% DEET. The extent to which DEET is refined is more important than the concentration over 30%.

* The following practices enhance the effectiveness of protection from mosquitoes and ticks when used in conjunction with repellents:
  - Cover as much exposed skin as possible. Consider loose fitting long-sleeved shirts in summer.
  - Tuck pants inside socks or boots to keep ticks out, or tape pants to boots.
  - Wear light-colored clothing to make seeing ticks easier.
  - Plan ahead and treat clothing with permethrin before your outdoor activity begins. Permethrin binds with fabric and is persistent through washings.
  - Store treated clothing in a plastic bag to help preserve repellent effectiveness and identify treated clothing.
Ticks and Tick-borne Diseases

The following information will help you avoid tick-related problems as you live, train, work, or play in or around the grassy or wooded habitats where ticks are found.

**IDENTIFICATION**

Unlike insects, adult ticks have eight legs, relating them more closely with spiders and scorpions. The tick's body is also fused into a single region instead of having the head, thoracic, and abdominal regions typical of insects.

There are two distinguishable families of ticks: (1) the hard ticks, which have hard smooth skin and an apparent head; and (2) the soft ticks with tough, leathery, pitted skin and no distinct head. The hard ticks are the ticks we most commonly find in the woodlands and on our pets. Soft ticks are generally less often observed and are found in caves and on birds. It is the hard ticks we associate with most of our common tick-borne diseases in the United States.

**For assistance in identifying ticks contact the local personnel in the pest control shop, Preventive Medicine Service, Health Clinic, or the Entomological Sciences Division, U.S. Army Environmental Hygiene Activity-South.**

**GEOGRAPHIC LOCATION**

Keep in mind that not all ticks carry a tick-borne disease, so a tick bite does not necessarily mean that disease will follow. However, there are several ticks that are potential vectors of tick-borne diseases. In the Northeast and Midwest is the deer tick (*Ixodes dammini*), reported to be the same species as the black-legged tick (*Ixodes scapularis*); the western black-legged tick (*Ixodes pacificus*) and the Rocky Mountain wood tick (*Dermacentor andersoni*) in the West; the black-legged tick in the South; and the American dog tick (*Dermacentor variabilis*) and Lone Star tick (*Amblyomma americanum*), which are found throughout much of the United States.

**LYME DISEASE**

The causative agent of Lyme disease is the spirochete bacteria *Borrelia burgdorferi*.

**Frequency**

Lyme disease has become the most common tick-borne disease in the United States. Cases have been reported in 48 states, with the greatest number of cases occurring every year in the northeastern states of Connecticut, Rhode Island, Massachusetts, New York, and New Jersey; in the upper midwest states of Wisconsin and Minnesota; and in the western states of California and Oregon. The disease is spreading rapidly, however, with an increasing number of diagnosed cases in the southeastern and southern states.

**Symptoms**

The most apparent and common symptom of Lyme disease, occurring in 50 to 85 percent of the cases, is a rash around the site of the tick bite. The rash appears within 3 days to 3 weeks after the
bite and expands in a ring or bull's eye pattern, with the center area clear. Other complaints include flu-like symptoms, such as fever, chills, headache, and extreme fatigue.

Although Lyme disease rarely causes death, the disease can cause a great deal of pain and discomfort if allowed to progress to later stages. If you have been in an area where ticks are found and you develop any of the symptoms mentioned above, especially during the period from May through early Fall, see a physician for evaluation immediately.

ROCKY MOUNTAIN SPOTTED FEVER

The causative agent of Rocky Mountain spotted fever (RMSF) is the rickettsial organism, *Rickettsia rickettsii*. 

**Frequency**

RMSF was originally found in the Rocky Mountains, but is now much more abundant in the Southeast and South-central United States. Oklahoma, North and South Carolina, Virginia, West Virginia, Georgia, and Tennessee often lead the nation in the number of reported cases of this disease.

**Symptoms**

Usually the first symptoms of RMSF appear 3 to 14 days after the tick bite and include sudden fever, chills, muscle aches, bloodshot eyes, and headaches. There may also be nervous symptoms, such as sleeplessness, restlessness, and delirium. In about 50 percent of the patients, a characteristic spotty rash occurs on the feet and hands within 2 to 3 days of the fever. The rash may move to the rest of the body, but does not start on the trunk of the body like the rash caused by measles and some other diseases. Although this disease can be effectively controlled with antibiotics following prompt treatment, fatalities do occur.

**HUMAN EHRlichIOSIS**

Human ehrlichiosis is caused by the rickettsial organism *Ehrlichia chaffeensis*.

**Frequency**

Human ehrlichiosis was first reported from Arkansas in 1986. It has been found in at least 11 other southern states.

**Symptoms**

Symptoms of Human ehrlichiosis can be very mild to severe, requiring hospitalization, and include fever, chills, headache, aches and pains in the joints and muscles, loss of appetite, eye pain, nausea, and vomiting. There is usually no rash.

**PREVENTION**

Wear clothing properly.

To greatly reduce your chance of tick bite, follow the DOD Repellent System of wearing proper clothing. Blouse or tuck your uniform legs into your boots and wear your sleeves down. Civilian should tuck their pant legs into their socks, and their shirt into their pants. Light colored clothing makes it easier to spot ticks.

In addition, when in the field, "buddy up" and routinely check for ticks every few hours or as frequently as possible. After returning, remove your clothing and check your body carefully. Pay special attention to hairy or warm, moist parts of the body.

**Use repellents.**

The DOD Repellent System also recommends applying deet repellent. NSN 6840-01-284-3982, to any exposed skin surfaces, and permethrin repellent spray, NSN 6840-01-278-1336, to your uniform or field clothing. *Never use permethrin on your skin.* The permethrin repellent is best applied to clothing prior to wearing. Allow the repellent to dry before using the treated clothing.

**ONCE BITTEN**

If you find a tick embedded in your skin, do not squash or burn it. Use tweezers to grasp the tick's mouthparts as close to the skin as possible, and pull it straight outward. Pull slowly, firmly, and steadily. Because the tick's central mouthpart is long and covered with barbs, it can be difficult to remove. Be patient. The prompt and careful removal of attached ticks greatly lessens the possibility of obtaining a tick-borne disease.

Wash the bite site and apply an antiseptic. Save the tick in alcohol or freeze it in a pill vial or plastic bag in case symptoms appear and identification of the tick becomes necessary. If symptoms do appear, seek medical attention immediately.
Human Ehrlichiosis

WHAT IS HUMAN EHRlichiosis?
(pronounced air-lick-ee-OH-sis)

Human ehrlichiosis is a tick-borne illness that is caused by an extremely small type of bacteria known as "ehrlichiae." Human ehrlichiosis is just one member of a group of diseases known collectively as "ehrlichioses," so named because they are each caused by a different species of ehrlichiae. Ehrlichiae invade and live within white blood cells. They belong to the family Rickettsiaceae, genus Ehrlichia. Ehrlichiae are closely related to rickettsiae, the type of bacteria that cause Rocky Mountain spotted fever (RMSF).

HISTORY

Ehrlichiosis was first recognized in 1935 as a disease of dogs (canine ehrlichiosis) caused by Ehrlichia canis. In the 1960s a number of military guard dogs stationed in Vietnam died from this disease. Human ehrlichiosis is a more recently recognized illness. The first diagnosed case occurred in 1986 in a 51-year-old man from Detroit who had been exposed to ticks in a rural area of Arkansas. In 1990, the agent of human ehrlichiosis was isolated from the blood of a U.S. Army reservist at Fort Chaffee, Arkansas. The new species of ehrlichiae was named E. chaffeensis.

Definition
Symptoms
Diagnosis and Treatment
Epidemiology
Prevention

SYMPTOMS

Symptoms of human ehrlichiosis begin in 1-21 (average 7) days following infection, and they resemble those of RMSF without a rash. Symptoms vary greatly in severity, ranging from an illness so mild that no medical attention is sought, to a severe, life-threatening condition. The most common symptoms are high fever, headache, chills, and muscular aches and pains, but may also include nausea, vomiting, loss of appetite, and an overall feeling of bodily discomfort. A spotted rash similar to that seen in RMSF, although usually less prominent and more variable in appearance and location, is present in only 20-40 percent of cases. Since E. chaffeensis invades white blood cells, the body's immune system is adversely affected. This lessens the body's ability to fight other infections, and complications can quickly arise. In the most severe cases, kidney or respiratory failure occurs. There have been a small number of deaths.

OTHER TYPES OF EHRlichiosis

Prior to the discovery of E. chaffeensis, E. senettsi was the only Ehrlichia species known to infect humans. E. senettsi causes Senettsi fever, a mononucleosis-type illness first described in 1954, and occurring primarily in Japan. Senettsi fever is very rare, and is usually extremely mild, with no deaths having ever been reported.

Most recently, the Journal of the American Medical Association reported 12 cases of what may be a new type of human ehrlichiosis (termed 'human granulocytic ehrlichiosis,' or 'HGE'), occurring in...
Minnesota and Wisconsin from 1990 through 1993. Two of the patients died from complications and secondary infections.

The species that causes HGE has not yet been conclusively identified, but differs from *E. chaffeensis* in that it attacks a different type of white blood cell. While *E. chaffeensis* infects white blood cells known as monocytes, the HGE organism infects white blood cells known as granulocytes. Clinical symptoms of both infections are the same.

Other species of *Ehrlichia* cause disease in animals, and include *E. ewingii* (canine granulocytic ehrlichiosis), *E. risticii* (Potomac Horse Fever), *E. equi* (disease in horses), and *E. phagocytophila* (disease in sheep and cattle).

**DIAGNOSIS AND TREATMENT**

A diagnosis of ehrlichiosis is confirmed by testing blood samples for antibody titers to different species of *Ehrlichia*, and by observing the bacteria in different types of white blood cells. The antibiotic doxycycline is very effective for treating both human ehrlichiosis and HGE. Because ehrlichiosis can be so severe, or even deadly, it is very important to obtain early diagnosis and treatment.

**DISTRIBUTION**

The incidence of human ehrlichiosis is unclear. The Centers for Disease Control and Prevention (CDC) recorded 339 cases from 27 states for the period 1985 through 1993, primarily based on blood samples sent to them for testing. Most cases were from Arkansas, Georgia, Missouri, Oklahoma, Tennessee, Texas, and Virginia.

**HOW IS EHRLICHIOSIS SPREAD?**

Both human ehrlichiosis and HGE appear to be tick-borne. The suspected vector for human ehrlichiosis is the Lone Star tick, *Amblyomma americanum*. This tick is very common in the south central and southeastern United States, where the majority of cases of human ehrlichiosis have been acquired. It is less clear which tick species transmits the causative agent of HGE, but there is some evidence that the American dog tick (Dermacentor variabilis) or black-legged tick (Ixodes scapularis, also known as the deer tick) might play a role. The brown dog tick, *Rhipicephalus sanguineus*, is the most likely vector of canine ehrlichiosis.

**PREVENTION**

Help prevent human ehrlichiosis, and other tick-borne diseases, by protecting yourself from ticks. When you are in tick habitat (tall grass and weeds, scrubby areas, woods, and leaf litter), follow these precautions:

- Wear the proper clothing — long pants tucked into socks or boots, long sleeve shirt, shirt tucked into pants, light-colored clothing to more easily spot ticks.
- Perform frequent tick checks. Ticks are often found on the thigh, groin, arms, underarms, legs, and scalp.
- Use a repellent containing permethrin on your clothing (NSN 6840-01-278-1336, aerosol spray; or NSN 6840-01-345-0237, individual impregnation kit for the field uniform) and a repellent containing deet (N,N-diethyltoluamide, NSN 6840-01-284-3982, long-acting lotion) on your exposed skin.
- Remove attached ticks as soon as they are found. Use tweezers to firmly grasp the tick's mouthparts up against the skin, and pull back slowly and steadily. Be patient — the tick's central mouthpart called the hypostome is covered with sharp barbs, sometimes making removal difficult. Don't pull back sharply, as this may tear the mouthparts from the body of the tick, leaving them embedded in the skin. If the mouthparts do break off, don't panic - the mouthparts alone cannot transmit disease because the infective body of the tick is no longer attached. However, to prevent secondary infection, remove the mouthparts as you would a splinter. Never squeeze the body of the tick or use such things as vaseline, fingernail polish remover, or a match while the tick is attached; these materials might agitate the tick and cause it to regurgitate infective fluid into the skin.
- After removal, wash the wound site, and apply an antiseptic. **SAVE THE TICK** in a jar or plastic bag for identification should you later develop disease symptoms. Preserve the tick by either adding some alcohol to the jar or by keeping it in the freezer. Identification of the tick may facilitate the physician's diagnosis and treatment.
- See a physician if you become ill after being exposed to ticks.
APPENDIX J - SAMPLE FORMS FOR SURVEILLANCE OF TICK VECTORS
AND THEIR HOSTS
U.S. Army Center for Health Promotion and Preventive Medicine
DOD TICK-BORNE DISEASE PROGRAM

SUBMISSION OF TICK SPECIMENS AND DATA FROM DEER

NOTE: Please fill out form for all deer that are processed (even when no ticks are found).

REPORTING FACILITY: INSTALLATION__________________________

POC________________________ PHONE DSN____________________

MAILING ADDRESS________________________

DATE OF TICK COLLECTION__________________ INSTALLATION SAMPLE NO.____________________

NAME OF COLLECTOR________________________

SOURCE OF TICK(S): INSTALLATION__________________________

CITY________________________ COUNTY________________________ STATE________________________

SERVICE (CIRCLE): ARMY NAVY AIR FORCE MARINES NAT’L GUARD OTHER________________________

SITE OF DEER HARVEST: HUNTING AREA________________________ OTHER________________________

DEER REGISTRATION OR TAG NO.________________________

DEER DATA: SPECIES (CIRCLE): WHITE-TAILED MULE OTHER________________________

SEX: M F WEIGHT No. POINTS AGE: FAWN YEARLING ADULT

TIME DEER KILLED________________________ TIME TICKS COLLECTED________________________

TIME SPENT LOOKING FOR TICKS: 5 minutes 10 minutes Other________________________

TICKS PRESENT? YES NO

TICK INFESTATION LEVEL: LOW (1-5) MED (6-25) HIGH (26-100) (> 100)

TICKS COLLECTED FROM: EARS HEAD/NECK CHEST ANO-GENITAL BACK

BLOOD SAMPLE OBTAINED? YES NO

BLOOD OBTAINED FROM: HEART BODY CAVITY VENIPUNCTURE OTHER________________________

LAB ANALYZING BLOOD/ADDRESS________________________

REMARKS________________________

PROJECT NO. (If any)________________________

CHPPM Form 309-R, 1 September 1997 (MCHB-TS-OEN)
U.S. Army Center for Health Promotion and Preventive Medicine
DOD TICK-BORNE DISEASE PROGRAM

SUBMISSION OF TICK SPECIMENS AND DATA FROM MAMMALS OTHER THAN DEER

NOTE: Please fill out form for all animals that are processed, even when no ticks are found.

**REPORTING FACILITY: INSTALLATION**

POC __________________________ PHONE DSN __________________________

MAILING ADDRESS __________________________

DATE OF TICK COLLECTION __________________________ INSTALLATION SAMPLE NO. __________________________

NAME OF COLLECTOR __________________________

SOURCE OF TICK(S): INSTALLATION __________________________

CITY __________________________ COUNTY __________________________ STATE ______

SERVICE (CIRCLE): ARMY NAVY AIR FORCE MARINES NATL GUARD OTHER __________________________

SITE OF COLLECTION: GRID COORDINATES __________________________

(CIRCLE): RANGE TRAINING RECREATION HOUSING CANTONMENT CLINIC OTHER __________________________

KIND OF ANIMAL:

<table>
<thead>
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<th>SPECIES</th>
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<td>PET DOG</td>
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<td>MILITARY WORKING DOG</td>
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<td>LIVESTOCK</td>
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<td>OTHER</td>
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</tr>
<tr>
<td>RABBIT</td>
<td></td>
<td>HISTORY OF DOG'S HOME LOCATION(S): __________________________</td>
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<tr>
<td>OTHER</td>
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</tbody>
</table>

SEX: M F WEIGHT __________ AGE: JUVENILE ADULT

BLOOD SAMPLE OBTAINED? YES NO

BLOOD OBTAINED FROM: HEART RETRO-ORBITAL VENIPUNCTURE OTHER __________________________

LAB ANALYZING BLOOD/ADDRESS __________________________

REMARKS __________________________

PROJECT NO. (IF ANY) __________________________

CHPPM Form 310-R, 1 September 1997 (MCHB-TS-OEN)
U.S. Army Center for Health Promotion and Preventive Medicine
DOD TICK-BORNE DISEASE PROGRAM

SUBMISSION OF TICK SPECIMENS AND DATA FROM ENVIRONMENTAL COLLECTIONS

NOTE: Please fill out form for all attempts to collect ticks (even when none are found).

REPORTING FACILITY: INSTALLATION__________________________

POC________________________ PHONE DSN____________________

MAILING ADDRESS________________________________________

DATE OF TICK COLLECTION________________________ INSTALLATION SAMPLE NO.________________________

NAME OF COLLECTOR________________________________________

SOURCE OF TICK(S): INSTALLATION________________________

CITY________________________ COUNTY________________________ STATE________

SERVICE (CIRCLE): ARMY NAVY AIR FORCE MARINES NATL GUARD OTHER________

SITE OF COLLECTION: GRID COORDINATES________________________

(CIRCLE): RANGE TRAINING RECREATION HOUSING CANTOINMENT OTHER________

HABITAT (CIRCLE ALL THAT APPLY): SCRUB OLDFIELD LAWN OTHER________

WOODED [ SPARSE MODERATE DENSE ] PREDOMINANT VEGETATION________________________

UNDERSTORY [ SPARSE MODERATE DENSE ] PREDOMINANT VEGETATION________________________

METHOD OF COLLECTION: WALK DRAG CO2 TRAP FLAG OTHER________

WEATHER CONDITIONS (CIRCLE ALL THAT APPLY): TEMPERATURE________

CLOUDY SUNNY DRY WET RAINING

REMARKS________________________

PROJECT NO. (If any)________________________

CHPPM Form 311-R, 1 September 1997 (MCHB-TS-OEN)
### Submission of Tick Specimens from Human Subjects

**Reporting Facility:** Installation

**POC:** __________ Phone: DSN __________

**Mailing Address:** __________

**Installation Sample I.D. No. (Do not use patient name or SSN):** __________

**Subject Residence [Circle]:** On-Post Off-Post

**Service [Circle]:** Army Navy Air Force Marines Nat'l Guard Other

**Status [Circle]:** Active Duty Retired Reserve Military Dependent DoD Civilian Other

**Age:** __________ **Sex:** M F **Race [Circle]:** Black White Asian/Pacific Islander American Indian/Alaskan Native Unknown

**When Did Tick Attach?** __________ **Date of Tick Removal:** __________

**How Long Was Tick Attached? (Hours):** __________ **Was Tick Removed at Clinic?** Yes No

**Where Was Tick Acquired:** On-Post (Installation) __________ Off-Post Unknown

**City:** __________ **County:** __________

**State:** __________

**[Circle]:** Range/Training Recreation Housing Home Cantonment Other

**[Circle]:** Field Woods Lawn Other

**Was This an Occupational Exposure?** Yes No

**Were Repellents Being Worn at the Time of the Tick Bite?** Yes No Unknown

**If Yes, Used on Skin:** __________ **Name of Repellent:** __________

**If Yes, Used on Clothing:** __________ **Name of Repellent:** __________

### Answer the Following Questions, as They Apply at the Time of Patient Visit:

**Describe Any Reaction to the Tick Bite (Check all that apply):**

- Erythema Migrans: Yes No
  - If Yes, less than 5 cm in diameter
  - Equal to or greater than 5 cm
  - Appeared within a few hours of tick bite
  - Appeared 2 - 3 days after the tick bite

- Constitutional Symptoms: Yes No
  - Headache
  - Swollen Glands
  - Arthralgias
  - Myalgias
  - Fever
  - Other

**Were Antibiotics Prescribed?** Yes No

**If Yes, What?**

**For How Long?**

**Was Lyme Serology Drawn?** Yes No

---

**Remarks:** __________

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CHPPM Form 321-R, 1 January 1998 (MCHB-TS-OEN) Replaces CHPPM Form 321-R, 1 Jul 96, which is obsolete.
# U.S. Army Center for Health Promotion and Preventive Medicine
## DOD TICK-BORNE DISEASE PROGRAM

### TICK ANALYSIS DATA SHEET

<table>
<thead>
<tr>
<th>Page ___ of ___ pages</th>
<th>Installation sample #</th>
<th>CHPPM sample #</th>
<th>Date rec’d:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identified by:</td>
<td>Call-in date (L.D.)</td>
<td>by:</td>
<td>Tested by:</td>
</tr>
</tbody>
</table>

### TICK IDENTIFICATION

<table>
<thead>
<tr>
<th>Species</th>
<th>Sex &amp; Stage</th>
<th>Engorgement</th>
<th>Condition</th>
<th>Mouthparts intact</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Amblyomma americanum</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lone Star tick</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Dermacentor variabilis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American dog tick</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ixodes scapularis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black-legged tick</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a.k.a. deer tick)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*Dead ticks cannot be tested*

### THIS TICK WAS TESTED FOR:

| Borrelia burgdorferi         | Pos | Neg | REMARKS: |
| (Lyme Disease)               |     |     |          |
| *Ehrlichia chaffeensis*      |     |     |          |
| (Human Monocytic Ehrlichiosis)|     |     |          |
| The agent of Human Granulocytic Ehrlichiosis |     |     |          |
| *Rickettsia rickettsii*      |     |     |          |
| (Rocky Mountain Spotted Fever)|     |     |          |

REVIEWED BY: