TICKS AND TICK-BORNE DISEASES

Stages of the Black-Legged ("Deer") Tick, *Ixodes scapularis*

I. HABITS OF TICKS

Ticks are members of the Class Arachnida of the Phylum Arthropoda. Other arachnids include spiders, mites, and scorpions. Ticks differ from insects in having the head, thorax, and abdomen fused into one body region (rather than the three separate regions found in insects), in having no antennae, and in having four pairs of legs as nymphs and adults. Insects, on the other hand, have one pair of antennae and have no more than three pairs of legs.

Ticks and mites are placed in the subclass Acari; ticks belong to the superfamily Ixodoidea. Ticks have four distinct life stages: egg, larva, nymph and adult. The larvae have six legs, while the nymphs and adults have eight legs. The Ixodoidea are further divided into two major families: hard ticks (Ixodidae) and soft ticks (Argasidae). In the United States, there are 55 species of hard ticks and 17 species of soft ticks. Both groups of ticks may transmit disease, although hard ticks are more important in terms of numbers of human cases of disease.

Most ticks parasitize a wide range of host animals -- amphibians, reptiles, birds, and mammals. When feeding, the tick makes an incision in the skin with its chelicerae (outer mouthparts), inserts the inner mouthparts (hypostome), and begins sucking blood. Both males and females feed on animal blood, but

females engorge to a larger size than males. Soft ticks become engorged in 15-20 minutes, but hard ticks may require several days for engorgement. Ticks are hardy animals and can endure long periods of fasting and inclement weather.

Hard Ticks

Hard ticks possess a hardened dorsal shield behind the anteriorly located capitulum (mouthparts). (See photo of black-legged ticks, above.) Hard ticks have a 3-host life cycle, with each feeding stage of the tick (larva, nymph, and adult) having a single host. Once replete, the tick detaches and, after dropping from the host, finds a resting place where it can digest its blood meal and molt to the next feeding stage. Male and female adult hard ticks can be distinguished from each other (called sexual dimorphism) in that the scutum, or dorsal shield, in the female is much smaller to allow greater engorgement. Mating generally occurs on the host, after which the females detach to digest their blood meal. They then lay one batch of thousands of eggs and then die. The time to completion of the entire life cycle may vary, but in temperate climates it is usually one to three years. Hard ticks may have one, two or three hosts, depending on species.

Their period of greatest activity is in the spring and early summer, when ticks are frequently found along animal trails in grass or brush. They crawl up the stems of grass or perch on the edges of leaves with their front legs extended (called "questing"). Passing hosts are detected through carbon dioxide, heat and movement. Ticks are very adept at creeping up one's body under clothing undetected. The bite of a tick is usually painless and may not be felt immediately. Ticks usually explore their hosts one to three hours before biting and becoming firmly attached. It may take several more hours of feeding for transmission of most tick-borne diseases to occur. Therefore it is important to carefully inspect for and remove ticks promptly. See “Personal Protection” under Section 3 for tick removal instructions.

Soft Ticks

Soft ticks lack a dorsal shield and have mouth parts located ventrally (see photo below). Six-legged larvae emerge from the eggs, take a blood meal, and molt to the first nymphal stage. Unlike hard ticks, many soft ticks go through multiple nymphal stages, gradually increasing in size until the final molt to the adult stage. Adults show no obvious sexual dimorphism. Soft ticks feed several times during each life stage, and females lay multiple small batches of eggs between blood meals during their lives. The majority of soft ticks are nest parasites, residing in sheltered environments such as burrows, dens and nests. They typically feed while the host is asleep, and engorge in a few minutes or hours, then return to their hiding place.

II. TICK-BORNE DISEASES IN THE UNITED STATES

Ticks are efficient vectors of viruses, bacteria, rickettsiae, and protozoa, and are able to cause paralysis by means of neurotoxic salivary secretions. Hard ticks have a number of attributes that enhance their vector potential. They attach themselves to their hosts firmly, feed slowly, and may go unnoticed for long periods. Many species may live for years and can withstand severe environmental stresses such as heat, cold, and long periods without feeding. They have few natural enemies and demonstrate an affinity for a wide variety of hosts. Some species can transmit disease-causing organisms (pathogens) to their offspring through the egg and from immature stages to adult. Females tend to lay large numbers of eggs and thus produce large numbers of offspring, although most of these do not survive into adulthood.

A. Tick Bite Paralysis

Tick bite paralysis is a progressive motor weakness caused by neurotoxic components of the tick's saliva injected by the feeding female tick. The symptoms are felt after the tick has fed for five to six days and begin with weakening arms and legs. Paralysis then progresses to the torso, face, tongue, and throat. In extreme cases, respiratory failure and death may result. Tick paralysis is most frequently seen in children; a favored site of tick attachment is the scalp. Removal of the tick produces a complete return of normal motor functions in one to three days. Only five species of North American ticks can cause paralysis, one of which, *Dermacentor andersoni*, is found in New Mexico. Cases of tick paralysis in New Mexico are rare.

B. Rocky Mountain Spotted Fever

Also known as tick-borne typhus fever, this disease is caused by an obligate intracellular bacterium called *Rickettsia rickettsii*. The incubation period is from 3 to 14 days. Symptoms include sudden onset of fever and chills, headache, severe muscle pain and bloodshot eyes. The name "spotted fever" refers to a rash that may appear two to four days after onset of the fever, usually beginning on the extremities and gradually spreading to most of the body. The case-fatality rate is about 5% per year; for untreated cases the case-fatality rate is 15 - 25%. RMSF is treatable with antibiotics.

Although first described from the Rocky Mountains, this disease is now most prevalent in the Ozarks (Missouri, Arkansas, Oklahoma) and Appalachians (North and South Carolina, Georgia, Kentucky, Virginia). It is transmitted by the bite of an infected tick or by contamination of abraded skin with crushed tick tissues or feces. The primary vectors in the U.S. are *Dermacentor variabilis* in the east and *Dermacentor andersoni* in the west. Several tick species maintain the infection in nature, especially *Haemaphysalis leporispalustris*, common on New Mexico rabbits. The rickettsia are passed transovarially (from the infected adult female to her eggs) and transstadially (from one life stage to another) in ticks, which are thus the reservoirs as well as the vectors of the disease. About 800 cases occur in the U.S. each year. New Mexico averages less than one case per year.

C. Tularemia (Rabbit Fever)

Tularemia is a plague-like disease caused by the bacterium *Francisella tularensis*. The symptoms include sudden onset of chills, fever, headache, malaise, diarrhea, and vomiting. Incubation period is usually 4 to 5 days, but can range from 1 to 14 days. There may be an ulcerated sore at the site of infection and lymph nodes are usually swollen, as in bubonic plague infection. The case fatality rate is about 1 - 3%. Untreated cases or pneumonic involvement increases mortality to 5 – 15%. Tularemia is treatable with antibiotics.

Tularemia is a rodent and rabbit disease and is transmitted among these animals by ticks. The rabbit ticks (*Haemaphysalis*) are able to pass the bacteria to their offspring and remain infected throughout their lifetime. People can get tularemia by direct contact with tissue and blood of infected rabbits and other animals, by the bites of *Dermacentor* or *Amblyomma* ticks, by rubbing tick feces into open cuts, and by the bites of deer flies (*Chrysops*). Spores of this bacterium can be found in dust, grains, and even water and can cause illness if ingested. The number of human cases in the U.S. has declined from 2300 in 1939 to an average of 150 – 300 per year today. Most cases occur in Arkansas, Missouri and Oklahoma. Although cases can appear year-round, seasonal peaks occur during winter rabbit-hunting season, and in the summer when people are outdoors and ticks and other vectors are abundant.

Preventive measures include avoiding ticks, deer flies, and other insects; wearing rubber gloves when handling wild animals; cooking any wild game thoroughly; and not drinking untreated water from streams, ponds or lakes.

D. Colorado Tick Fever

This viral disease is spread by ticks from ground squirrels and other small rodents. The primary vector is the Rocky Mountain wood tick, *Dermacentor andersoni*. This disease is short in duration, has low mortality, and is characterized by sudden onset of a high fever (which disappears for one to three days in the middle of illness only to return), headache, muscle pain, reduction of white corpuscles in the blood, and infrequently rash. The incubation period is 3 to 6 days. Because it is a virus, antibiotic therapy is ineffective. Although considered a mild illness, convalescence can be prolonged. Human cases occur in the western U.S. and Canada within the range of the vector tick *D. andersoni* above an elevation of 5,000 ft. Most cases occur during the spring/summer tick season. The number of cases annually varies from 65 to 250; about 100 cases per year are reported from Colorado.

E. Tick-borne Relapsing Fever

Caused by bacterial spirochetes in the genus *Borrelia*, relapsing fever is spread by soft ticks of the genus *Ornithodoros* in the western U.S. A feverish period lasting for two to nine days alternates with an afebrile period of two to four days, after which the fever returns. Along with fever, symptoms include chills, headache, muscle and joint aches, abdominal pain, and malaise. The incubation period is about seven days. The number of relapses of fever in untreated patients varies from two to ten or more. The fatality rate in untreated cases is about 2-10%. The disease is treatable with antibiotics. Relapsing fever is not transmitted from person to person.

Each species of soft tick that is a vector of relapsing fever carries a spirochete that is host-specific. Thus, the tick *Ornithodoros hermsi* transmits the spirochete *Borrelia hermsi*; *O. parkeri* is the vector for *Borrelia parkeri* and so forth. Cross-infection apparently does not occur. The ticks remain infective for life and pass the spirochetes on to their offspring. Reservoir hosts include pine squirrels (*Tamiasciurus hudsonicus*) and chipmunks (*Tamias* sp.), whose nests may be infested with infective *Ornithodoros* ticks. Tick-borne relapsing fever is a highly focal infection, often associated with rustic mountain cabins where, in the absence of humans, ticks transmit the disease between small mammals, especially rodents, nesting in these cabins.

Outbreaks of relapsing fever may involve many people exposed to the same tick source. As an example, in the summer of 1973 an outbreak at the North Rim of the Grand Canyon in Arizona involved 27 park employees and 35 overnight visitors. Infections were associated with sleeping in rustic cabins and being bitten by "unknown insects". Infective *O. hermsi* ticks were recovered from chipmunk nests found in walls and attics of the cabins. The ticks had sought human hosts after their rodent hosts had been killed by disease or poison. Another outbreak occurred in the same area in the summer of 1990 resulting in 6 cases. The outbreak was apparently triggered by a decline in rodent populations resulting in the ticks seeking out new hosts. The rodent decline may have been due to a plague epizootic. Relapsing fever cases are rare in New Mexico; two cases occurred in Colfax County in the summer of 1996, and an outbreak at a gathering in San Juan County in August 2002 resulted in 11 cases.

Since the *Ornithodoros* ticks normally feed on sleeping people during the night, and do not become attached, tick prevention measures differ from hard ticks. Rodent-proofing cabins and homes where rodents may seek shelter is the most effective method of preventing relapsing fever. Staying out of caves in which rodents have sought shelter is also worthwhile, as wood rats may also be sources of ticks.

F. Lyme Disease

This disease is a relative newcomer to the world of tick-borne diseases, being noted first in the U.S. in the 1970's at Old Lyme, Connecticut. The causative agent is a spirochete called *Borrelia burgdorferi*, named for Dr. Willy Burgdorfer who discovered it in 1982. The symptoms of Lyme disease include a distinctive "bull's-eye" type of skin rash, called erythema migrans. An estimated 85% of persons with symptomatic Lyme disease have this characteristic rash. Other symptoms may include chills, fever, malaise, fatigue, headache, joint and muscle aches, and swollen lymph nodes. Neurological symptoms resembling those of encephalitis and aseptic meningitis may appear a few weeks or months later. Cardiac abnormalities may also appear later, and swelling and pain in the knees and other joints may lead to chronic arthritis. Fatalities are rare, but the effects of the disease may persist for months or even years with or without treatment. Treatment with antibiotics is most effective when Lyme disease is in its earliest stages. The incubation period is three to 32 days after the bite of an infective tick.

Lyme disease is often difficult to diagnose because its symptoms and signs mimic those of many other diseases. Diagnosis of Lyme disease should take into account 1) history of possible exposure to ticks, especially in areas where Lyme disease is known to occur; 2) symptoms and signs;

3) results of blood tests used to determine whether the patient has antibodies to Lyme disease bacteria. These tests are most useful in later stages of illness, but even then they may give inaccurate results. Some laboratory tests for Lyme disease are more reliable than others, and inconsistent or incorrect testing has resulted in high numbers of false positives in the past (for more information see the CDC's Lyme disease diagnosis webpage at http://www.cdc.gov/NCIDOD/DVBID/lyme/ld_humandisease_diagnosis.htm).

Lyme disease is spread by the black legged tick (commonly called deer tick) *Ixodes scapularis* in the Northeast and North-Central states and by *Ixodes pacificus* on the Pacific Coast. The life cycle of the deer tick takes two years to complete. The tick needs three hosts to complete its life cycle. Larval ticks feed on white-footed mice (*Peromyscus leucopus*); tick nymphs feed on mice, birds, and man. Adults prefer white-tailed deer (*Odocoileus virginianus*), although they will accept substitutes of man and rodents. The white-footed mouse acts as a reservoir for the spirochete and suffers no ill effects from it. Although white-tailed deer are important hosts of the adult ticks and help maintain the tick population, they are not reservoirs for the spirochete and do not infect ticks feeding on them.

The spirochete is not passed from the adult female to the eggs; however, the disease is maintained and spread to uninfected ticks through the nymphs. Tick nymphs emerge in the spring and early summer, prior to larvae of the previous year. Infected nymphs feed on *P. leucopus* and infect the mice. When the larvae emerge and feed on the mice, they in turn become infected. Ticks are then infective for life. The nymphal stage is more likely to transmit Lyme disease to humans. Their small size (less than 2 mm) makes them harder to detect and remove. Thus, the nymphs have ample time to feed and transmit the infection (ticks are most likely to transmit infection after approximately 2 or more days of feeding). Larval ticks rarely carry the infection at time of feeding; adult ticks, though they may be infected, are more likely to be found on a person's body and removed.

Cases occur primarily during the summer months, when tick and human populations outdoors are greatest. During 2006, the most recent years for which CDC has compiled data, a total of 19,931 cases of Lyme disease were reported in the U.S., making it the most common vector-borne disease in the country. Although virtually every state in the continental U.S. has reported cases of Lyme disease, 95% of cases occur in the Northeast (Maryland to Maine) and North-central states (Wisconsin and Minnesota). Cases reported by the New Mexico Department of Health in New Mexico residents have been acquired in Lyme-endemic areas. No cases are known to have been acquired within the state. Elsewhere, Lyme disease is known from almost all of Europe, the USSR, and Australia.

For Lyme disease to exist in an area, at least three closely interrelated elements must be present in nature: the Lyme disease bacteria, ticks that transmit them, and mammals (such as mice and deer) to provide food for the ticks in their various life stages. Ticks that transmit Lyme disease can be found in temperate regions that may have periods of very low or high temperature and a constant high relative humidity at ground level. Neither *Ixodes scapularis* nor *Ixodes pacificus* are found in New Mexico. See the attached table for a list of hard ticks from New Mexico.

Other species of ticks have occasionally been found infected with *Borrelia burgdorferi* or other closely related *Borrelia*, such as *Ixodes dentatus* in eastern North America, *I. spinipalpis* in western North America, and *Amblyomma americanum* in the eastern and south-central United States. These other ticks may not be competent vectors of Lyme disease to humans, however.

Unlike most other tick-borne disease, Lyme disease has a peridomestic reservoir and exposure. In Westchester County, New York in 1985, 69% of all cases acquired the disease in their own yards. Increased deer populations in suburban areas are also posing a risk. Removing leaves and clearing brush and tall grass around houses and at the edges of gardens may reduce the numbers of ticks that transmit Lyme disease. Removing plants that attract deer and constructing physical barriers may help discourage deer from coming near homes.

A Lyme disease vaccine was licensed in 1998 but removed from the market in 2002 because of declining sales and less than ideal efficacy. No human Lyme disease vaccine is currently available in the U.S. There is a canine vaccine for dogs that live in Lyme-endemic areas.

G. Human Ehrlichioses

During the last decade, two previously unknown human diseases caused by *Ehrlichia* species have emerged as public health problems in the U.S. *Ehrlichia* are bacteria related to the rickettsiae. Canine ehrlichiosis is a disease of dogs spread by the brown dog tick (*Rhipicephalus sanguineus*). Human monocytic ehrlichiosis (HME) is caused by *Ehrlichia chaffeensis*, and human granulocytic anaplasmosis (HGA) is caused by *Anaplasma phagocytophilum*. From 1986 through 1997, 1,223 ehrlichiosis cases were reported by 30 state health departments in the United States.

Human Monocytic Ehrlichiosis

Most patients reported a tick bite within the 3 weeks prior to onset. Symptoms have included fever, headache, myalgia, anorexia, nausea, vomiting, rash, cough, pharyngitis, diarrhea, lymphadenopathy, abdominal pain and confusion. Severe complications leading to death may occur. Three-fourths of patients are male; median age of patients is 44 years. Cases are predominately rural, and 68% occur during May – July.

The causative agent, *Ehrlichia chaffeensis*, has been detected in two tick species, the Lone Star tick, *Amblyomma americanum*, and the American dog tick, *Dermacentor variabilis*. Most HME cases have occurred within the range of *A. americanum* (south-central and southeastern U.S.) White-tailed deer are considered to be a reservoir for this pathogen.

Tetracycline has been found to be an effective treatment for HME.

Human Granulocytic Anaplasmosis

Cases of HGA have been reported predominately in the upper Midwestern and northeastern states. This is also a potentially fatal illness with nonspecific symptoms including chills, fever, malaise, myalgias, headache, nausea, vomiting, cough, confusion and rarely rash. Patients are predominately older men and peak occurrence is in June and July. Doxycycline is the treatment of choice for HGA. The vector of HGA is *Ixodes scapularis*. Rodents and/or deer may be a reservoir.

III. CONTROL OF TICKS

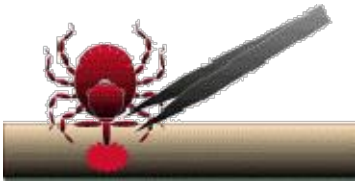
(Portions of this section were obtained from the "Tick Management Handbook" © 2004, Connecticut Agricultural Experiment Station).

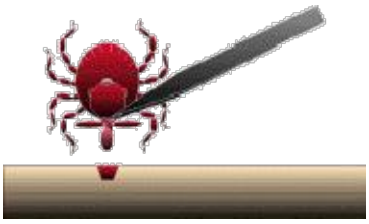
Personal Protection

Checking for ticks and prompt removal of attached ticks is probably the most important and effective method for preventing tick-borne disease. Ticks do not jump, fly or drop from trees, but grasp passing hosts from the leaf litter, tips of grass, etc. Wear light-colored clothing with long pants tucked into socks to make ticks easier to detect and keep them on the outside of the clothes. Avoid sitting in grass or on logs in brushy areas and don't sit under low bushes and shrubs.

Use a DEET or permethrin-based mosquito and tick repellent. Use DEET-based repellent on exposed skin and clothing (do not use DEET under clothing or on irritated skin). Treat clothing with permethrin-based repellent; spray clothing until thoroughly moistened, then allowed to dry 2-4 hours before wearing. Always follow label directions and precautions.

After being outdoors, remove clothing and wash and dry it at a high temperature; inspect body carefully and remove attached ticks with tweezers. Check very closely on the head and neck under hair for attached ticks. If you find an attached tick, grasp the tick with tweezers as close to the skin as possible. Remove the tick with a slow steady pull that will not break off the mouthparts and leave them in the wound (see drawings below). Anything else, such as holding a lighted match to the tick, may cause the tick to regurgitate its stomach contents into the bite, increasing the chance of transmitting disease. Apply an antiseptic to the bite and wash your hands thoroughly if you touched the tick, as even the secretions from the tick are infective.





Ticks can be preserved for identification by placing them directly into a small vial containing alcohol. Seal this vial into a plastic bag and send to the Zoonoses Program of the New Mexico Department of Health in Santa Fe along with information on where the tick was collected.

Tick Control on Dogs

Dogs are frequently infested with ticks. A variety of products can repel and/or kill ticks on the animal. Some are available over the counter (OTC) and others only through your veterinarian. Chemical products to protect dogs from ticks are available as spot-ons, sprays, collars, powders and dips. Ingredients include several insecticides such as pyrethrin, permethrin, amitraz, fipronil or imidacloprid.

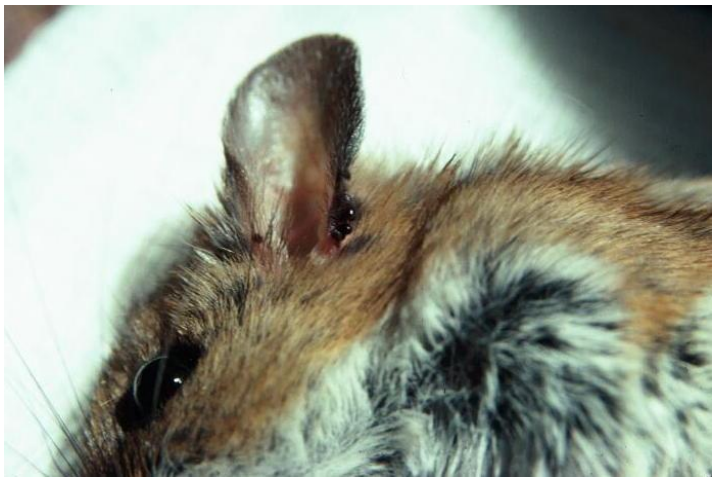
Follow label directions to minimize the chances for an adverse reaction in your pet, and do not combine products without the advice of your veterinarian. Treat the dog, its blankets, its kennel and doghouse with approved pet treatments. Washing or disposal of the dog's blankets will also be necessary.

Landscape Management

Woodlands, brushy areas and groundcover vegetation provide suitable tick habitat. Fewer ticks are found in ornamental vegetation and lawn. Ticks also favor the transition zone between manicured lawn and woods or brush. Around the home, reduce tick numbers by keeping grass mowed short, removing weeds and leaf litter and trimming shrubs and tree branches around the lawn edge. Restrict the use of groundcover vegetation in areas frequented by family members and pets. Bright, sunny areas are less likely to harbor ticks. Adopt xeriscape-landscaping techniques by using gravel pathways and mulches, particularly between the lawn and wooded or brushy areas. Move firewood piles and bird feeders away from the house.

Host-Targeted Chemical Control

In Lyme disease-endemic areas, where mice and chipmunks act as intermediate hosts for deer ticks, bait boxes that treat rodents are placed around the home. A non-toxic bait is placed inside, and in order to get to the bait, the rodent must pass under a wick impregnated with an insecticide, usually fipronil. This approach has been shown to be effective for reducing deer tick populations and the number of infected nymphs. This approach has not been evaluated for the brown dog tick, the most common tick pest in New Mexico.



Ticks attached to ear of deer mouse

Area Pesticide Applications

Insecticides are the most effective way to reduce ticks, particularly when combined with landscape management to reduce tick habitat. Insecticide application should be timed to coincide with emergence of adult or nymphal ticks in the late spring/early summer (depending on tick species) and again in the fall. A single application of most ornamental-turf insecticides will provide 85-90% or better control with some residual activity, so multiple applications are usually not necessary. Only spray tick habitats (such as groundcover vegetation, woodlands or brushy areas bordering lawns) and only use a product

specifically labeled for controlling ticks. Synthetic pyrethroids are the most commonly used acaricides, and may be available in both liquid and granular formulations. Carbaryl (Sevin®) is also labeled for tick control. Do not treat herb, vegetable or butterfly gardens. Avoid fishponds; pyrethroids are highly toxic to fish. As with all pesticides, carefully read and follow all label directions and precautions.

Hard Ticks of New Mexico

List compiled by Pamela J. Reynolds[1] and Ted L. Brown[2]
[1]New Mexico Department of Health and [2]New Mexico Environment Department (retired),
Santa Fe, NM
Based on tick surveys and literature records

Tick Species	Comments
Aponomma elaphense	Parasite of snakes
Dermacentor albipictus	Called the "winter tick"; parasite of deer and elk
D. andersoni	Rocky Mountain wood tick, disease vector
D. hunteri	
D. parumapertus	Found on hares and rabbits
Haemaphysalis leporispalustris	Rabbit tick
Ixodes angustus	Rodent tick
I. conepati	Found in caves and burrows on variety of animals
I. hearlei	
I. kingi	Rotund tick; found on carnivores and rodents
I. sculptus	Parasite of rodents
I. soricis	Parasite of shrews
I. spinipalpis (includes species formerly known as *neotomae*)	Parasite of wood rats and mice
I. texanus	Raccoon tick
I. woodi	Woodrat tick
Rhipicephalus sanguineus	Brown dog tick, most common tick in the world and in New Mexico