

SUMMIT VetPharm ECTOPARASITOLOGY SYMPOSIUM



ARTICLE 1 **ADVANCES IN COMPANION ANIMAL TICK CONTROL**

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Ticks are important blood-feeding ectoparasites of dogs, cats, and people.^{1,2*} Tick infestations can result in anemia, allergic dermal reactions, paralysis, and other forms of toxicosis. They also serve as efficient vectors for numerous disease agents. Ticks and mites (e.g., scabies mites and ear mites) are members of the order Acarina. The two tick families of interest in veterinary medicine are the ixodid, or hard ticks, and the argasid, or soft ticks.² They differ in structure, ability to expand when feeding, and developmental cycles. The ixodid ticks are of primary interest in companion animal parasitology and are the focus of this article. Common ixodid tick characteristics are summarized in *Table 1* (page 2). See pages 3 and 5 for photos of adult and immature ixodid ticks.

Although similar in structure to mites, ixodid ticks are larger and possess a leathery shield, or scutum, on their dorsal surface. The scutum covers the entire surface of adult male ticks but only a portion of the dorsal surface of female ticks. The presence or absence of iridescent white or yellow patches on the scutum of adult ticks is useful in identifying the different species. Ticks with these colorful markings are called ornate ticks (e.g., *Amblyomma*, *Dermacentor*), and

those without them are called inornate ticks (e.g., *Rhipicephalus*, *Ixodes*).

Tick life cycles

Ixodid ticks develop through four distinct life cycle stages: egg, larva, nymph, and adult.² Ticks increase in size as they develop from larva to adult. Larvae, nymphs, and adults are similar in appearance but differ in size and the number of legs (larvae possess six legs; nymphs and adults possess eight legs). Larvae and nymphs, unlike adults, do not possess features of sexual dimorphism. Hard ticks that infest pets are referred to as three-host ticks because the larva, nymph, and adult stages use different hosts during their life cycles. The brown dog tick (*Rhipicephalus sanguineus*) is a notable exception in that all stages of *R. sanguineus* usually infest dogs. Consequently, it can be difficult to eradicate from kennels and homes. The numbers of hosts used by some ticks can be formidable. For example, the Eastern black-legged tick (*Ixodes scapularis*) may parasitize in excess of 100 different host species of reptiles, birds, and mammals.² After each stage feeds to repletion, it drops from the host, molts to the next stage, and seeks a new host. This “on the host, off the host” cycle continues until the adult female tick drops

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Table 1 - COMMON TICKS FOUND ON DOGS OR CATS

Tick	Common name	Geographic distribution	Seasonal activity
<i>Amblyomma americanum</i>	Lone star tick	Southeast, Midsouth, coastal Northeast	Spring to fall
<i>Amblyomma maculatum</i>	Gulf coast tick	Coastal South, but expanding northward (OK, KS, KY)	Summer through fall
<i>Dermacentor variabilis</i>	American dog tick	Eastern U.S., including Northeast, Southeast, Midwest, also coastal western U.S.	Spring through fall; greatest activity in summer
<i>Dermacentor andersoni</i>	Rocky Mountain wood tick	Northwestern U.S., northern Rocky Mountain states	Spring through summer
<i>Ixodes scapularis</i>	Eastern black-legged tick	Eastern U.S., including Northeast and Southeast, also Upper Midwest	Nymphs in spring; adults in fall
<i>Ixodes pacificus</i>	Western black-legged tick	Coastal western U.S.	Nymphs in spring; adults in fall
<i>Rhipicephalus sanguineus</i>	Brown dog tick	Throughout U.S.	Throughout year; greatest activity spring through fall

from the final host to lay eggs. It does so in a sheltered environment to protect eggs from climatic extremes and predators. Larvae hatch from eggs, and the cycle begins again. Certain ticks, such as *R. sanguineus*, can complete their life cycle in weeks, while others, such as *Dermacentor* and *Ixodes*, can require two years or more.

Most hard ticks find their hosts by questing on vegetation. As hosts pass nearby, questing ticks literally grab them and search for a suitable attachment site. Ticks attach to hosts first by cleaving to the host's skin with a component of their mouthparts called chelicerae. They then insert an anchoring device called the hypostome to ensure that they remain tenaciously attached during feeding. Some ticks produce a cement-like substance that also aids in attachment. Feeding and engorgement usually require several days for each stage and are enhanced by substances in their saliva that inhibit host immune responses, inhibit coagulation of blood, and exert local anti-inflammatory and analgesic responses.³ Engorged larvae, nymphs, and adults drop from the host to either molt to the next stage or produce eggs in the case of engorged adult female ticks.¹

Ticks as vectors of disease

Ticks are efficient transmitters of disease for several reasons: they require relatively large blood meals and may feed on hosts for prolonged periods; they are not easily removed during feeding because of their hypostomes and cement-like attachment

substances; and they produce numerous substances in their saliva that promote feeding. As the different stages feed, they ingest pathogens that may be circulating in the host's blood. Ingested pathogens replicate in the tick and are disseminated to a variety of sites, including the salivary gland. Tick-borne pathogens enter the dog, cat, or person when the subsequent stage (after molting) feeds on a susceptible host. This is referred to as trans-stadial or stage-to-stage transmission (*i.e.*, a larva or nymph acquires the pathogen, a nymph or adult transmits it). Transmission can also occur via the tick's joint fluids and regurgitated gut contents. Some pathogens, such as *Rickettsia rickettsii*, the cause of Rocky Mountain spotted fever, are passed from female ticks to their ova. This is referred to as transovarial or female tick-to-ovum transmission. Larvae that emerge from those ova can then infect a new host with the pathogen when the larvae feed.⁴

A tick's competence as a disease vector depends on several factors, such as size of blood meal, capability of the pathogen to infect the tick and replicate within it, successful dissemination of the pathogen throughout the tick's body, trans-stadial or transovarial transmission of the pathogen, and interactions between multiple microbes infecting the same tick. Selected vector-borne diseases of dogs and cats and their tick vectors are included in *Table 1*. A more detailed summary of human and animal vector-borne diseases is presented in the article on page 6.

Tick-borne diseases (dogs or cats)

Ehrlichiosis (*Ehrlichia ewingii*, *Ehrlichia chaffeensis*), tularemia (*Franciscella tularensis*), *Borrelia lonestari*

American hepatozoonosis (*Hepatozoon americanum*)

Ehrlichiosis (*Ehrlichia canis*, *E. chaffeensis*), Rocky Mountain spotted fever (*Rickettsia rickettsii*), tularemia (*Franciscella tularensis*), feline cytauxzoonosis (*Cytauxzoon felis*)

Rocky Mountain spotted fever (*R. rickettsii*), tularemia (*F. tularensis*)

Lyme borreliosis (*Borrelia burgdorferi*), anaplasmosis (*Anaplasma phagocytophilum*)

Lyme borreliosis (*B. burgdorferi*), anaplasmosis (*A. phagocytophilum*)

Anaplasmosis (*Anaplasma platys*), babesiosis (*Babesia canis*, *Babesia gibsoni*), ehrlichiosis (*E. canis*), Rocky Mountain spotted fever (*R. rickettsii*)



Unengorged female of *Amblyomma americanum*

Several safe and effective tick-control products are available for use on dogs or cats.* Active ingredients in these products include amitraz, fipronil, and permethrin. Amitraz is a formamidine compound that inhibits monoamine oxidase, which is responsible for metabolism of amine molecules that serve as neurotransmitters in susceptible mites and ticks. Amitraz paralyzes ticks, including their mouthparts, making them incapable of attaching to and feeding on their hosts. Fipronil is a phenylpyrazole compound that disrupts the function of gamma aminobutyric acid (GABA)-mediated neurons. Target ticks are paralyzed and unable to attach to their hosts. Permethrin is a third generation synthetic pyrethroid that interferes with the opening and closing of sodium ion channels in nerve membranes. Affected nerves undergo repetitive discharges resulting in rapid paralysis of the tick. Permethrin and certain other synthetic pyrethroids are also effective repellents for certain ectoparasites. It is unclear whether permethrin's effect is due to its rapid action or its repellent properties. The former seems more likely because ticks often easily gain access to their hosts; they are probably killed or forced from their hosts by the rapid paralytic effects of permethrin.

Laboratory studies have demonstrated that tick control products help prevent transmission of disease agents.⁵⁻¹¹ It is important to remember that these studies were under controlled conditions in laboratory environments—more variables exist under conditions of actual product use.

Dependence on tick control products alone cannot provide adequate assurance that pets will not be exposed to tick transmitted diseases. Veterinarians should develop a comprehensive approach to controlling ticks and vector-borne diseases, including use of available tick control products year-round as recommended by the Companion Animal Parasite Council (www.capvet.org), vaccines when available, and reasonable tick avoidance strategies.

*To view references and a list of tick control products, see pages 9 to 10.

Tick control

A successful tick control program prevents tick attachment and feeding and transmission of infectious agents from ticks to their hosts. Complete success is not easily achieved, given the variety of tick species and differences in their host preferences and life cycles. Successful tick control combines modification and treatment of environments around the home or kennel, avoidance strategies to prevent exposure to questing ticks, and the use of on-animal tick control products.

Environmental control involves destroying tick and host refuge areas, such as brush piles around buildings. This will eliminate sheltered areas for environmental ticks as well as habitats for rodents and rabbits that serve as hosts for immature ticks. Acaricides can be applied to these areas to kill ticks. If *R. sanguineus* is a problem, it is important to target indoor areas, such as cracks in floors and areas above suspended ceilings. Using a licensed pest control specialist is the best means of ensuring safe acaricide use. All treated surfaces should be dry before pets are allowed to contact them.

Tick avoidance strategies are helpful in decreasing pet exposure to ticks. Veterinarians should become familiar with the prevalence and seasonal habits of tick species in their area. Pet owners should avoid tick-infested environments, especially during seasons when tick populations are increased. When walking pets, they should remain in the center of trails that are free of weeds, long grass, or overhanging vegetation.

COMPANION ANIMAL FLEA CONTROL: NEW ADVANCES AND TECHNIQUES

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Companion animal flea control has improved markedly in the last 10 years, primarily because of new products on the market that control fleas successfully. These products have involved the veterinarian in a pet's health more intimately than when products targeted the environment or were sold for application to pets without the veterinarian's direct involvement. Before the advent of these products, the veterinarian's role was mainly to handle pets' toxic reactions to misapplied products. The veterinarian's direct role in helping to control flea infestations has made the world of the flea a much less hospitable place than it once was.

However, fleas are only beaten back, not completely gone. The most important flea for veterinarians in the United States is *Ctenocephalides felis felis*, the subspecies of the cat flea found around the world. Other subspecies, such as *C. felis strongylus*—an even more voracious blood feeder from Africa—have fortunately not adapted to such a worldwide existence.^{1*} Also, the cat flea, *Ctenocephalides felis*, has forced the closely related dog flea, *Ctenocephalides canis*, out of existence in most of North America and Europe.² Therefore, dogs and cats are both hosts mainly to the same species, *C. felis*. The cat flea is not restricted to dogs and cats, however; it is capable of infesting a number of other hosts, including coyotes, red and grey foxes, bobcats, skunks, several rodents, raccoons, opossums, and ferrets.³ Thus, we must always remember that although we are not seeing cat fleas on pets in a given area, they are liable to be right around the corner or under the house on our semidomestic urban companions: the opossum and raccoon.

Even though fleas may seem under control most of the time, frequent recurrences can frustrate pet owners. Fleas may reappear in days, weeks, or even seasonally. The appearance of fleas a few days after a household begins a successful treatment is called the pupal window⁴ and is typically due to the eclosion of adults from environmentally resistant pupal cocoons. Another problem is the development and persistence of several stages in the flea life cycle in areas where a pet may rest (e.g., on an old blanket in the basement, under the porch, in the yard between the house

and the pool). In these places, large numbers of eggs, larvae, and pupae may be present, and if the specific site is not treated, adult fleas may be produced for several weeks to perhaps months—especially if the pet chooses to spend time elsewhere for awhile and, therefore, the adult fleas are not stimulated to leave their protective cocoons. Finally, the cat flea cannot live at temperatures below freezing, but the fleas can survive winters on the bodies of raccoons and opossums.³ Therefore, it is important that clients remain ever diligent and keep their cats and dogs on a prevention program even when there are no apparent fleas in the household.

Flea control strategies

Initially flea control consisted simply of cleanliness, sunlight, and frequent washing of wooden floors with brine, kerosene, or even gasoline. One researcher suggested that infestations in the house could be eliminated by the elimination of animals, but this solution would be quite difficult for most pet owners.⁵ Over the past century, flea control in buildings has gone through various manifestations from fumigation (e.g., sulfur, hydrocyanic gas, or naphthalene), to the use of botanical insecticides (e.g., pyrethrum from chrysanthemums and rotenone from the roots of certain bean plants, such as *Derris* and *Lonchocarpus*), synthetic derivatives, and finally organophosphate compounds.⁶ For the treatment of dogs and cats, people early in the control process also recommended dusting pets with rotenone powder (deris powder), rubbing pyrethrum into the fur, or pulverizing naphthalene mothballs and working the powder into the animal's fur; however, this is a poor option because these highly toxic chemicals can often cause adverse reactions in pets.⁶

Today, things are much improved. The major products that are approved to kill and repel fleas on dogs and cats have margins of safety well beyond those that were used until just a few years ago; relatively speaking, these new products are remarkably environmentally friendly. Very small portions of topical products are applied to animals—applied once a month. The doses are below the toxic levels of the substances, even if they were to be taken orally.

A new generation of fleas

Unfortunately, the battle that has raged against fleas has caused a number of products to be less effective than they once were. For years, there has been selection for fleas capable of surviving in the presence of these molecules. Thus, it appears that fleas are becoming more and more tolerant of doses of different insecticides: organophosphates (chlorpyrifos and malathion), carbamates (carbaryl), third generation pyrethroid (permethrin), and synthetic pyrethrum (pyrethrin).⁷ Strains of *C. felis* collected from around the United States (e.g., Decatur, Ala., Anaheim, Calif., Lake Worth, Fla., Wichita, Kan., Gastonia, N.C., Greensboro, N.C., and San Antonio, Texas) revealed some level of tolerance to most of these compounds.⁷ Thus, there is a constant need for new products with new modes of action.

Dinotefuran, a new neonicotinoid insecticide, could be a useful candidate because it

exhibits low mammalian toxicity and effective insecticidal activity against a broad range of pests.⁸ Neonicotinoids, the newest major class of insecticides, have been shown to have outstanding potency and systemic action for crop protection and flea control on cats and dogs.⁹ Common names among this group are acetamiprid, clothianidin, dinotefuran, imidacloprid, nitenpyram, thiacloprid, and thiamethoxam. These chemicals are believed to have low toxicity to mammals (with acute and chronic use) because of the low affinity of neonicotinoids for vertebrate nicotinic receptors relative to those of insects. It is hoped that dinotefuran will enter the veterinary profession as a useful addition to existing chemistries. It will give us a new tool in continuing advances in flea control, propelling us even further away from the best-forgotten days of salt water and cyanide gas.

*To view references, see page 10.

TICKS PHOTO REFERENCE



Unengorged male of *Amblyomma maculatum*

For more information on ticks, see *Advances in companion animal tick control* (pages 1 to 3). Photos courtesy of Dr. Byron L. Blagburn.



Unengorged male of *Rhipicephalus sanguineus*



Unengorged male of *Dermacentor variabilis*



Unengorged larva of *Dermacentor variabilis*



Unengorged female of *Ixodes scapularis*



Unengorged nymph of *Dermacentor variabilis*

CANINE EHRLICHIOSIS AND ANAPLASMOSIS: COMMON TICK-BORNE PATHOGENS IN DOGS

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Ehrlichia species are a group of tick-transmitted, intracellular, gram-negative bacteria in the family Rickettsiaceae. The organisms that cause the diseases currently known as canine ehrlichiosis and anaplasmosis are in the genera *Ehrlichia*, *Anaplasma*, and *Neorickettsia*. This article will focus on organisms in the genera *Ehrlichia* and *Anaplasma*. These organisms may reside in one or more host blood cell types including granulocytes, monocytes, and platelets. Each species has a fairly strong predilection for a specific cell type, thus categorizing most infections as either granulocytic or monocytic. In addition, one species of *Anaplasma*, *Anaplasma platys*, is known to infect platelets.

Several *Ehrlichia* and *Anaplasma* species are known to infect dogs (see page 8) and the clinical presentations may differ, depending on the organism involved. Although any of these agents can be transmitted by blood transfusions from infected animals, most infections are tick-transmitted. Ticks are capable of harboring and transmitting the rickettsial disease for several months after they are infected, making them important reservoirs. Ticks also serve as an amplifier of infection since organisms multiply in the tick gut and salivary gland epithelium before transmission. This article highlights the clinical findings, laboratory diagnosis, and treatment of agents responsible for most clinical cases of canine ehrlichiosis and anaplasmosis: *E. canis*, *E. chaffeensis*, *E. ewingii*, *A. phagocytophilum*, and *A. platys*.

Monocytic ehrlichiosis

The monocytic form of canine ehrlichiosis is arguably the most common form worldwide, but in some areas of the United States, depending on the tick populations present, granulocytic infections may be more prevalent. Canine monocytic ehrlichiosis may be caused by *E. canis* or *E. chaffeensis* and has a worldwide distribution.

E. canis is transmitted by the brown dog tick, *Rhipicephalus sanguineus*, and the primary vector for *E. chaffeensis* is the lone star tick, *Amblyomma americanum*. The organisms are transmitted through the saliva during a tick bite. They invade the monocytes or lymphocytes in the blood, liver, spleen, bone marrow, lymph nodes, lung, kidney, and central nervous system where they form membrane-bound morulae that may contain up to 50 or more bacteria.

CLINICAL SIGNS AND LABORATORY FINDINGS

Natural infections with *E. canis* or *E. chaffeensis* cause diseases that can be clinically similar. The clinical course of disease is well characterized for infections with *E. canis*. There are three phases of canine monocytic ehrlichiosis: acute, subclinical, and chronic. Clinical signs usually start one to three weeks after infection and, during the acute phase of the disease, are typically mild and consist of fever, depression, anorexia, weight loss, ocular and/or nasal discharge, and, rarely, signs of hemorrhage. The most consistent laboratory finding is thrombocytopenia, but anemia and leukopenia may also occur.

During the subclinical phase, few if any clinical signs are observed. Even so, many animals experience mild thrombocytopenia, hyperglobulinemia, and a high antibody titer against *E. canis*. Some animals can remain subclinically infected for years and never develop clinical disease; however, some will advance from a subclinical phase to develop chronic, clinical ehrlichiosis. The cause for this remains unclear, but it is speculated that concurrent illness; co-infection with other tick-borne agents; immune stressors, such as trauma, surgery, or drug therapy; and breed susceptibility may play a role in the development of chronic ehrlichiosis.

In the chronic phase of the disease, clinical signs may be mild or severe. Severely affected dogs are often febrile with clinical signs of weakness, depression, anorexia, weight loss, bleeding disorders, and pale mucous membranes. Less frequent signs include ocular and nasal discharge, peripheral lymphadenopathy, edema, retinal lesions, ataxia, hepatomegaly, splenomegaly, and possibly death. Laboratory findings include severe thrombocytopenia (greater than 80% of cases), nonregenerative anemia and/or leukopenia, hyperglobulinemia, and elevated liver enzymes. The severity of disease varies with the pathogenicity of specific organism strains and individual differences in host-defensive mechanisms (e.g., pups generally are affected more severely than adults).

DIAGNOSIS

It is rare to diagnose canine monocytic ehrlichiosis by recognition of morulae in blood monocytes. The diagnosis is generally suspected based on clinical and routine laboratory findings and positive serology. The serologic assays most widely used are

the indirect fluorescent antibody (IFA) test, which is available at most commercial laboratories, and the SNAP® 3Dx® Test and SNAP® 4Dx® Test (IDEXX Laboratories, Westbrook, Maine) for in-clinic use. The IFA test uses whole *E. canis* organisms cultured in a canine macrophage cell line as the reacting antigen. The assay is difficult to interpret with many false positives due to cross-reactivity and background staining.

The SNAP 3Dx and SNAP 4Dx assays use synthetic peptides based on a major outer membrane protein of *E. canis*. This reduces the number of false positive results seen with IFA, giving the assay a very high positive and negative predictive value. The new SNAP 3Dx and SNAP 4Dx tests have increased specificity and sensitivity over the older SNAP® 3Dx® Canine Combo.

Animals infected with *E. canis* or *E. chaffeensis* will test positive using any of the currently available serologic assays. The only way to distinguish between these two infectious agents is by in vitro cultivation or polymerase chain reaction (PCR) analysis. Therefore, the role of *E. chaffeensis* as a cause of canine monocytic ehrlichiosis is poorly defined. PCR analysis can be performed by many commercial laboratories and may be one way to identify a seropositive animal as having an active infection. However, a negative PCR reaction does not rule out infection because many subclinically infected animals have organisms in the peripheral blood at levels below the sensitivity of the PCR test.

TREATMENT AND PROGNOSIS

During a routine exam, if a clinically normal animal is found to be positive on serology, this indicates the animal has been exposed to ehrlichiosis and could be a carrier in the subclinical stage of the infection. A CBC should be performed to identify any characteristic hematologic abnormalities, such as a mild nonregenerative anemia or thrombocytopenia. If blood abnormalities are found, the patient should be treated appropriately and retested in three to six months. If no abnormalities are found, the need to treat the animal is not clearly established. Minimally, a serologic evaluation should be repeated in three to six months. If persistently positive, a course of therapy should be considered.

Tetracycline (20 mg/kg orally three times a day) or doxycycline (5 to 10 mg/kg orally twice a day) treatment for four weeks is generally effective in eliminating clinical signs, but titers (especially high titers) may persist for long periods of time. Animals cleared of infection should have a gradual decline in antibody titer, and a titer reduction of

50% to 75% in a six-month period may indicate that therapy has effectively eliminated the organisms. Blood transfusions may be required in severe cases. Clinical improvement in response to therapy precedes the return of hematologic parameters to normal, which may take months in severe cases.

With treatment, the prognosis is excellent in acute cases and mildly affected chronic cases but guarded in cases with severe pancytopenia and hypoplastic or aplastic bone marrow. Low dose tetracycline (7 mg/kg/day) has been recommended as a prophylaxis in dogs at high risk for reinfection.

Granulocytic forms of disease

The granulocytic forms of these diseases are recognized as such because the organisms have a tropism for circulating granulocytes, particularly neutrophils. There are two main organisms that are known to infect dogs: *E. ewingii* and *A. phagocytophilum* (formerly *E. equi*). Infections with these agents have been reported across the United States, and a particularly virulent strain of *A. phagocytophilum* has been reported to cause clinical disease in dogs in Sweden.

E. ewingii has been reported in dogs in several U.S. states, including Arkansas, Oklahoma, North Carolina, and Virginia. Infections in people have been reported in Missouri, Oklahoma, and Tennessee. The only confirmed tick vector is *Amblyomma americanum*. The white-tailed deer is suspected to be an important reservoir for infection, similar to *E. chaffeensis*.

Infection with *A. phagocytophilum* has been recognized in a variety of hosts, including people, dogs, cats, horses, ruminants, and many wildlife species, such as white-tailed deer, dusky-footed wood rats, mountain lions, and bears. Canine infection with *A. phagocytophilum* was first reported in dogs from Minnesota and Wisconsin in 1996. In the United States, most disease outbreaks are seasonal and coincide with the emergence of the tick vectors in spring and early summer (May and June) and then again in September.

CLINICAL SIGNS AND LABORATORY FINDINGS

Vague clinical signs, similar to those seen with monocytic ehrlichiosis, occur in dogs with the granulocytic form of the disease as well. These include fever, lethargy, anorexia, and reluctance to move. The predominant and most characteristic clinical sign is lameness due to suppurative polyarthritis, which makes the clinical findings of these diseases indistinguishable from those seen in Lyme disease. *A. phagocytophilum* and the agent of Lyme disease (*Borrelia burgdorferi*) share the same tick vector, *Ixodes* ticks or deer ticks, and have a similar geographic

distribution in the United States. Because of this, co-infections with these two organisms commonly occur and may result in more severe clinical manifestations than infections with a single agent.

Laboratory findings include a mild to moderate nonregenerative anemia, thrombocytopenia, and lymphopenia with or without neutropenia. The most common hematologic abnormality is a mild to severe thrombocytopenia, seen in more than 80% of acutely infected dogs.

DIAGNOSIS

Diagnosis can often be made by microscopic identification of *Ehrlichia* or *Anaplasma* morulae in neutrophils in the peripheral blood or synovial fluid. These are most often found during the acute phase of the disease (one to 10 weeks post-infection), and they may be seen in between 1% to 15% of circulating neutrophils. At this point we have no serologic assay available for *E. ewingii*, although some animals infected with *E. ewingii* may have a positive reaction on assays that detect *E. canis*. IFA tests are available for the serologic diagnosis of infection with *A. phagocytophilum* and PCR assays have been designed to specifically amplify portions of the 16S rRNA gene of this organism. An in-house ELISA assay (SNAP® 4Dx® Test—IDEXX Laboratories, Westbrook, Maine), is now available for in-clinic use. This test identifies animals infected with *A. phagocytophilum* but will not cross react with animals infected with *E. ewingii*. It is also important to note that animals infected with *A. phagocytophilum* will not test positive on assays designed to diagnose *E. canis* infections (SNAP 3Dx Test).

TREATMENT AND PROGNOSIS

The treatment for the granulocytic forms of ehrlichiosis and anaplasmosis is oral doxycycline at 10 mg/kg twice a day for 30 days. Clinical signs typically resolve shortly after institution of therapy. However, evidence in both people and dogs shows that some infections with *A. phagocytophilum* will not be cleared and that carrier states can occur even with appropriate antimicrobial therapy.

Zoonosis

Of the tick-borne diseases discussed, *A. phagocytophilum* most commonly affects both dogs and people. To the author's knowledge, direct transmission from dogs to people has never been documented. Ticks serve as a biological vector and amplifier for the organism. However, infected pets should signal to owners the presence of infected ticks in the environment with due caution for tick control.

TABLE 1: EHRlichia AND ANAPLASMA SPECIES KNOWN TO INFECT DOGS

- *E. canis*, *E. ewingii*, and *E. chaffeensis*
- *Anaplasma phagocytophilum* (formerly *E. equi* and the human granulocytic ehrlichiosis agent)
- *Anaplasma platys* (formerly *E. platys*)
- *Neorickettsia risticii* (formerly *E. risticii*)

Infectious cyclic thrombocytopenia

Anaplasma platys (formerly *Ehrlichia platys*) causes infectious cyclic thrombocytopenia in dogs. This agent is unique in that it is the only intracellular infectious agent described in people or animals to specifically infect platelets. The prepatent period is one to two weeks following experimental injection with infected blood. Cyclic parasitemias and concomitant thrombocytopenia occur at one- to two-week intervals. Parasitized platelets are easily found during the initial parasitemia, but subsequent parasitemias have decreasing percentages of parasitized platelets. Platelet counts usually remain below 20,000/μl for only one or two days before rapidly increasing. Infected dogs usually do not exhibit evidence of illness, but mild fever may occur at the time of the initial parasitemia. Minimal or no evidence of hemorrhage is present in most cases, but epistaxis, petechia, and ecchymosis of mucous membranes have been reported. The infection can be diagnosed by observing organisms within platelets. An IFA test for antibodies against *A. platys* has been developed. Cross-reaction with other *Ehrlichia* species is not likely. However, animals infected with *A. platys* will test positive on the SNAP 4Dx. *A. platys* can be identified using PCR technology, but this is not commercially available. Doxycycline at the dose described previously is effective in treating this infection.

Summary

Canine ehrlichiosis and anaplasmosis are emerging tick-borne diseases in dogs, endemic to several areas of the United States and expanding in distribution. In addition to causing clinical disease, dogs may be subclinical carriers of persistent infection, causing a positive serology result in healthy dogs. These dogs should be monitored closely because there may be potential for clinical manifestations, particularly after events of stress or immunosuppression. Finally, doxycycline is effective in treating the clinical disease but may not clear the organisms from all infected animals.

SELECTED TICK CONTROL PRODUCTS

Chemical Name	Trade Name	Target Host	Spectrum*	Dosage and Regimen	Formulation	Other Information
Amitraz	Preventic® Tick Collar For Dogs	Dog	RS, DV, AA, IS	1 collar/dog	9.0% collar	For use on dogs 12 weeks and older. Do not use on cats. Kills ticks for three months.
Fipronil	Frontline® Top Spot	Dog and cat	CF, RS, DV, AA, IS	Apply to skin monthly based on weight; use appropriate size for weight range	9.7% fipronil	Good residual activity. Rapid killing. Combination of fipronil and methoprene (Frontline® Plus) provides activity against adult and immature fleas. Frontline spray contains 0.29% fipronil. Some formulations also have control or aid in control claims for chewing lice and SS.
	Frontline® Plus		CF, RS, DV, AA, IS		9.8% fipronil 11.8% fipronil, 8.8% (S)-methoprene	
Imidacloprid-permethrin	K9 Advantix™	Dog	CF, RS, DV, AA, IS, Mos.	Apply to skin monthly based on weight; use appropriate size for weight range	8.8% imidacloprid 44.0% permethrin	Good residual activity and rapid killing for fleas. Permethrin has repellent and antifeeding properties. It is more stable than prototype pyrethrins. For use on dogs 7 weeks and older. Do not use this formulation on cats.
Metaflumizone-amitraz	ProMeris™ for Dogs	Dog	CF, RS, DV, AA, IS	Apply to skin monthly based on weight; use appropriate size for weight range	14.34% metaflumizone 14.34% amitraz	Good residual activity and rapid killing for fleas. Amitraz helps prevent ticks from attaching and feeding. For use in dogs and puppies 8 weeks and older. Do not use this formulation on any animals other than dogs.
Selamectin	Revolution®	Dog	CF, OC, SS, DV	6 mg/kg applied to skin every 30 days based on weight	6% or 12% spot-on; tubes contain 15, 30, 45, 60, 120 or 240 mg of selamectin	Also effective against precardiac <i>D. immitis</i> in dogs, and precardiac <i>D. immitis</i> , <i>T. cati</i> , and <i>A. tubaeforme</i> incats. Approved for use in dogs 6 weeks and older and cats 8 weeks and older.
		Cat	CF, OC			
Dinotefuran-permethrin-pyriproxifen	Vectra 3D®	Dog	CF, RS, DV, IS, AM, CU, OT, AE	Apply to skin monthly based on weight	4.95% dinotefuran, 36.08% permethrin, 0.44% pyriproxifen	Good residual activity. Features a unique patented applicator and Bloodhound Technology™.

*CF=*Ctenocephalides felis*, OC=*Otodectes cynotis*, RS=*Rhipicephalus sanguineus*, DV=*Dermacentor variabilis*, AA=*Amblyomma americanum*, IS=*Ixodes scapularis*, SS=*Sarcoptes scabiei*, Mos.=Mosquitoes, CU=*Culex* spp, OT=*Ochlerotatus* spp., AE=*Aedes* spp.

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