

# Quiet Killers: Tick-Borne Disease in Dogs

by Gil Ashe

If you live where ticks are never seen from one year to the next, you don't have to worry about protecting your dog from tick-borne disease unless you travel with him. If you live in the South, one of the South Central states, the Southwest, the Northeast, one of the coastal states, or if there is a deer on your lawn, prevention is something you should be taking seriously, both on your dog and in your environment.

Environmental prevention is based on what we know about the hard-bodied tick, a creature which seems to be geared toward only two things, reproduction and survival, both of which depend on blood. When an adult female tick has been impregnated by one of the much smaller males and has gorged itself on the blood of an animal, it falls off and dies after laying a batch of eggs that may number in the thousands. The tiny, six-legged larvae that emerge from the eggs do not all survive or we would be overrun with them, but those that do survive attach themselves to small mammals like field mice and have their first blood meal. This is where the trouble for dogs can start if that mouse is a carrier-host for tick-borne disease since ticks are not usually born infected.

Having fed once, the larvae molt, develop into nymphs and gain another pair of legs and the chance to become a carrier if the larger animal they feed on this time has a TBD, or to pass infection along if they are already vectors. Molting a second time, they become adults and instinct drives them to make their last meal so they can reproduce and assure the continuation of their species.

The Lone Star tick will actually chase a likely meal, but most ticks will only climb up a grass stalk or crawl along a low-hanging tree branch to a good vantage point and wait for your dog to come along, holding up their little front legs as if in anticipation of grabbing hold. In actuality, they have chemoreceptors in sensory organs on their front legs, something like little taste buds that test the air, and they use them to find their next meal. They know us by the carbon dioxide we and our dogs breathe out, moisture, our body heat and a chemical that all mammals give off, butyric acid, which smells to us like dirty socks but is ambrosia to a tick because it means dinner is coming. So when your ambrosial dog brushes by one, it will latch onto his fur and start looking for a good place to attach and feed. (Ticks do not jump but they will drop onto a dog - or you - if either of you is close enough.)

The way the tick behaves, the means it uses to sense us and our dogs, give us clues on how to keep them away, and while most ticks may not carry disease, they exist in such numbers that it only makes sense to do everything possible to protect our dogs from being bitten instead of playing the odds that one of those bites won't be from an infected tick.

Clear away all brush and tall grass in your environment. Trim back low-hanging tree limbs and keep dogs away from stone walls or woodpiles with all those little niches where mice that might carry TBD and ticks can hide. Spray deer repellent around the perimeter of your property if they come to visit as deer are the number one host for the black-legged deer tick that can transmit several TBDs. If you know there are a fair number of ticks in your surroundings, you can put a few inches of a mild dish soap like Ivory liquid in a garden sprayer and spray the outside of your house and your yard with it. But do it in the evening when the beneficial honey bee isn't around because the soap that will kill tick larvae and nymphs will kill them. Rain, of course, will undo your efforts so until you've managed to reduce the tick population, you may have to spray several more times.

If your problem is worse and you have no close neighbors to offend, you can use a garden spreader to put down granulated sulphur wherever you want to repel ticks. Their little sensory organs really do not like granulated sulphur, which smells like rotten eggs to us, and for some people who have had a really bad infestation it has worked very well in getting ticks to beat a

hasty retreat. Powdered sulphur will work but it does not stick to the ground as well and will have to be reapplied after a good rain. Even making a barrier of sulphur around your yard, if you cannot take having it all over the place, will provide a measure of protection.

Dry ice tick traps which rely on the tick's attraction to carbon dioxide are another way to get rid of ticks. According to a study of tick collection methods done in 1992, dry ice-baited tick traps were by far the most effective way of collecting ticks, over 5,000 of them caught as compared to less than a hundred by someone just walking through an area filled with host-seeking ticks. Easily made with a styrofoam cooler and masking tape, these traps may not get all the ticks in the yard but they will significantly reduce the number.

If the worst happens and you see scores of ticks crawling the walls inside your house, forget trying to handle the problem yourself. Call a professional exterminator and move out for a while to let them work and allow the chemicals time to dissipate before you move back in. Drastic problems call for drastic solutions sometimes, whether we like them or not, but be sure you get a guarantee that the exterminators will come back if necessary.

### Tick Preventives

Preventives take the battle to the dog, not only protecting them from the adult ticks which are easy to spot, but from the nymphs that may be as small as the period at the end of this sentence and difficult or impossible to see and remove. So, a good preventive is a must in tick season, which peaks in spring and fall.

Those listed below have proven themselves to be excellent choices for preventing TBD, both in research studies and in actual use by countless numbers of dogs. You have to realize, though, that nothing is perfect and there will be failures. Don't forget to check your dog for visible ticks and see to it that he's tested at least once a year.

The Preventic Collar made by Virbac sets the standard for tick preventives. The active ingredient is Amitraz. If you use the collar, you must read and follow the directions on how to fit it. It has no effect on fleas and takes 24 hours to provide complete protection. Rain doesn't affect it but immersion in water is not a good idea so a dog wearing the Preventic collar won't be swimming. Do not use it on sick dogs. Amitraz is toxic to cats and the maker cautions against using it if cats snuggle up to your dog. It is highly toxic if it is ingested so if there is a chance that your dog, or another dog he tussles with, would get it in his mouth, pass it by. The Preventic collar is in wide use and if none of the situations noted above are likely to come up, it is quite possibly the best product to use.

Frontline TopSpot and Frontline Spray are made by Merial. The active ingredient in Frontline is fipronil. TopSpot is applied directly to the skin between the dog's shoulders according to the manufacturer, though speaking from experience, dotting it in several places along the spine from shoulder to tail is less messy. Spreading over the dog, it settles in the sebaceous (oil-secreting) glands at the base of each hair and grows up with the fur, taking about 48 hours to cover completely. When a tick finds its way onto the dog, it has to slog through a forest of fur impregnated with Frontline, which works by paralyzing it. Even if it manages to attach, the odds are high that the tick will not be able to feed and transmit disease before it dies.

Frontline Spray is especially good for dogs that have very short or dry coats which don't have a lot of oils in them. It is also good for spot spraying when you need quick coverage on places like the belly and feet.

A rare few dogs are sensitive to Frontline. If you are at all worried that your dog might be one, sacrifice one of the small vials by applying only a single drop to his skin so that any discomfort he might have will be limited to a small area. You should know inside a day if he is going to have a reaction. Frontline may be removed, if necessary, by using a shampoo that contains benzoyl peroxide. It retains its effectiveness in water so a dog protected by Frontline can swim.

K9Advantix, made by Bayer, has also been around long enough to rack up a good record for safety and efficacy and it, too, is often recommended by vets. It is a topical like Frontline TopSpot, works in much the same way and also remains effective after swimming. K9Advantix contains two main ingredients: permethrin, which repels and kills ticks and mosquitoes, and imidocloprid, which kills fleas and flea larvae. Permethrin is toxic to cats so be aware of this if you think of using K9Advantix and have cats that live peacefully in close proximity with your dog and sometimes groom him. If they do, it would be best to choose another tick preventive. Do not stretch the time between applications! There is some real concern that ticks might survive the continually shrinking amount of Frontline or K9Advantix left on the dog after the recommended 30 day reapplication time and become immune to it. One thing we do not need is ticks that are immune to the few weapons we have to use against them. Whatever preventive you choose, however, one of these or another, read the label. It's there because it carries information you need to make an informed decision.

#### Natural tick preventives

No tick preventive is going to be an absolute guarantee against tick-borne disease but some are definitely better than others and all of these are commercial products. People who are concerned about using chemicals on their dogs often turn to so-called natural preventives, either making them from essential oils themselves or buying them ready-made. What they forget is that natural oils are chemicals, they are simply not man-made chemicals. Not being man-made, they have not gone through the rigorous testing that every commercial tick preventive undergoes, both for safety and how well they work. Nor can the ready-made natural products provide any documented proof on either score. For that reason, they are not named or recommended here.

#### Vaccine prevention

The Lyme disease vaccine is the only one available to prevent a tick-borne disease in dogs. Whether or not it should be used is a matter of some debate and too involved to go into here. Briefly, the vaccine appears to work best on dogs which have never been exposed to Lyme disease, i.e., very young dogs in areas considered hot spots. It must be given every year. Dogs have been known to get Lyme even though they have been vaccinated. Most of the veterinary teaching hospitals do not recommend it unless you live in an area where there is a strong likelihood of infection. The ease with which Lyme can be detected and treated may weigh against using the vaccine. Very rarely, dogs can have a reaction to the vaccine which leaves them with all the painful symptoms of Lyme disease but no hope of being cured as there is no disease there to fight. Unfortunately, you cannot know if yours will be one of them before you vaccinate. That said, many dogs have been vaccinated, suffered no serious reaction and appear to have been protected by the Lyme disease vaccine.

Testing and treatment - When to test, what tests to run and what to do if test results are positive  
"I had to 'fire' my vet before I could get the proper treatment for my Cocker Spaniel, Ricky. It was almost a year before I could get the correct diagnosis and by that time, his digestive system was permanently damaged. I just spent this morning cleaning up poop and vomit and crying. He will certainly not live a normal life span. I will forever regret that I did not know about TBDs sooner." ~ Felicia Mazur

The answers did not come easily or soon for Felicia and her Ricky, who seemed to have Inflammatory Bowel Disease and now probably does, given his scarred intestines. Weight was dropping off him even though he ate well. His energy level had plummeted, and (though this is not always a symptom) his eyes were bloodshot and weeping. You'd think Ricky would have been tested for tick-borne disease as a matter of course since Felicia lives in an area where ticks are far from rare and he was not responding well to treatment. It's not as if testing is invasive or expensive, certainly not expensive when compared to so many other things dogs are put through in the search for a diagnosis. So why wasn't it done?

While those of us who have watched our dogs die of tick-borne disease, or have seen them damaged for life as Ricky was, vehemently disagree, it would seem that TBD is not dangerous or

wide-spread enough to be given much attention by the veterinary schools and journals responsible for educating vets. There are still many vets who do not even think of it when they start to determine what might be wrong with a dog. So, as you may have guessed, "when" to test is up to those of us not lucky enough to have a vet on our side who is knowledgeable about TBD. Because Ricky's vet didn't test and for a long time Felicia didn't know to ask, she went through the misery of seeing her dog get sicker without knowing why and without any hope he would get better until, at last, she got a new vet, a diagnosis and something to fight. But the delay was costly. After a period of doing fairly well, Ricky began having trouble again and is now on chemo for intestinal lymphoma.\*

If there are ticks in your area, educate yourselves about the early signs you can recognize yourself: diarrhea, lethargy, a lack of interest in food, changes in behavior, fever, and above all, lameness, which is the number one presenting symptom. If you suspect your dog has been infected, have your veterinarian send a blood serum sample for a comprehensive TBD panel to a laboratory with special expertise in TBD testing even if he or she tells you that it is useless and a waste of money. It is your dog and your money and without testing nobody can say that tick-borne disease is impossible. Even at the risk of appearing foolish or being wrong, insist! Pam Barbe, MT (ASCP), who maintains an extensive website on Samoyed health, told me something once I will never forget, nor should you. "You are your dog's only advocate," she said; "if you won't stand up for him, who will?"

#### Testing for TBD

As vigilant as we might be, the early signs of TBD can be easy to miss or to dismiss as nothing important. So our best line of defense, apart from having a good vet and using a proven tick preventive, is to make testing at least once a year a regular part of our dogs' health care.

#### Snap tests

Snap tests are done in-house by your vet and take only minutes to show results for heartworm, *E. canis*, and Lyme disease on the Snap 3DX, adding *A. phagocytophilum* on the newer Snap 4DX. They are yes/no tests which only tell you whether or not one of those diseases was detected, not how low or high the antibody count might be. The Lyme portion of the test is as good as they get right now, showing very few false positives or negatives. Based on technology patented by IDEXX Laboratories, Snap tests are available to your veterinarian only from them. Blood samples may be sent directly to IDEXX for testing if your vet doesn't have them at present.

A positive Snap test for Lyme disease should be followed up immediately by sending a blood sample to IDEXX to have a Quantitative C6 Antibody Test run. The Quant C6 provides a baseline number of antibodies which will be invaluable six months later when you run this test again. The magic number is 30 units per millileter. Over that, you treat. If the number of antibodies has fallen by 50% when you retest, treatment is considered successful.

A drawback of the Snap 4DX is that its TBD tests are limited to Lyme, *A. phagocytophilum* and *E. canis*. While those are the most prevalent TBDs at the moment, there are others which can be equally serious. If there are clues in your dog's regular bloodwork, a CBC or blood chemistry panel, which point to TBD, and/or you still believe that he has one based on your knowledge of your dog despite a negative Snap test, your next option is to have an IFA tick panel run. As a side note, never underestimate the value of having regular bloodwork done, both to establish a baseline of what is normal for your dog and to monitor any changes if he becomes ill.

#### IFA tests

Indirect Fluorescent Antibody tests give results based on titers. Titers are derived from blood serum samples which are suspected of containing antibodies the immune system makes to fight disease. The serum is diluted to a standardized starting point, for instance, 1:20, then that is diluted further by doubling the dilution over and over so that the series might go like this: 1:40, 1:80...on up into the tens of thousands in some instances. Or as Dr. Beckett explains it, "starting with the lowest dilution (e.g., 1:20), a same-size sub-sample from each successive dilution is

tested until...at some point the serum is so dilute that the sub-sample contains too little antibody to trigger a reaction. The highest dilution which DID show a reaction is reported as the 'titer'."

Unfortunately, with tick-borne disease, you can never depend on easy answers. A high titer is not necessarily an indicator of a really bad infection. It may mean that a dog has a very strong immune system which is going all out to eradicate the invader. Conversely, a low titer may not mean you have nothing to worry about. Diane Polito's Corgi, Calvin, a feisty little dog who loved to compete, was half way to his Master Agility Championship until *A. phagocytophilum* cost him his ability to walk without a cart and eventually his life, though he never mounted a titer higher than 1:80.

The best laboratory in the country for a tick-borne disease panel, in my estimation and that of many others, is ProtaTek in Chandler, Arizona. Run by Cynthia Holland, Ph.D., who has published many peer-reviewed papers on tick-borne disease, ProtaTek is accurate and fast. Moreover, Dr. Holland is extremely helpful when questions arise about which tests to run and what those results really mean.

### PCR Tests

Polymerase Chain Reaction tests ignore antibodies and look for DNA of the disease itself. If DNA of a specific TBD is in a sample of blood or organ tissue, they can find it. Their usefulness is limited, however, because there are few reliable laboratories with the expensive equipment needed for PCRs or the people qualified to run them and turnaround time can be slow. Dr. Ed Breitschwerdt, whose Tick Borne Diagnostic Laboratory at NC State is one of those few, recommends running at least 3 PCRs to rule the presence of a TBD in or out. A generic PCR test is now available at NC State which can be followed up by specific tests if results are positive for tick-borne disease. NC State does not, however, do PCRs for *N. risticii*.

Oh, Lord, he's positive!

No dog owner who is aware of what TBD is and what it is capable of doing can escape the feeling that the bottom has just dropped out of his or her world when handed a diagnosis of tick-borne disease. But don't lose heart if it happens to you. There are effective weapons in your arsenal. Here they are.

### Doxycycline

The drug of choice for every TBD except babesiosis is doxycycline (Vibramycin), a semi-synthetic tetracycline which is processed mainly through the liver, works by inhibiting the ability of bacteria to reproduce, and has a superior ability to penetrate cells to reach the organisms it targets.

There is some dispute about how much doxycycline to use in treating TBD and for how long. On Tick-L, an Internet list for people dealing with tick-borne disease in dogs, most of us who have lived through the fight, some more than once, believe you should hit it hard and for an extended period in an effort to knock it out and prevent it from recurring. We believe and recommend that the dosage should be 10 milligrams per kilogram of body weight given every 12 hours for 6 to 8 weeks. For those who, like me, are metrically challenged, this is close enough to 5 mg. per pound. The standard treatment, as recommended in the Merck Veterinary Manual, is 5 to 10 mg/kg once a day for 10 to 21 days.

Tom Beckett, DVM, our advisor and mentor on Tick-L, has worked with rescued greyhounds and shelter dogs for more than 25 years; in that time, approximately a quarter of the large number he has treated for TBD had it recur when he used the standard protocol. He now prefers to treat dogs aggressively, as recommended above. Suzanne Stack, DVM, who has treated large numbers of rescued greyhounds in Arizona for *E. canis*, agrees and has made aggressive treatment standard practice. Steven Levy, VMD, who has studied Lyme disease for more than 20 years and diagnosed the first case of canine Lyme carditis, treats with doxycycline at 10 mg/kg twice a day for 28 days. In *The Five Minute Veterinary Consult*, Max Appel, DVM, Ph.D., Emeritus

Professor at Cornell, has also indicated a preference for treating Lyme disease with the high-end dose of doxycycline. In Greene's Infectious Diseases of the Dog and Cat, the dosage of doxycycline for the treatment of Lyme is given as 10 mg/kg every 12 hours for a minimum of 30 days; while at ProtaTek, Dr. Holland finds end-point titers for *E. canis* extremely important in determining treatment protocol, chronically infected dogs requiring a "more rigorous and lengthy treatment". As yet, however, many vets appear to prefer the standard treatment protocol for all stages and until more studies are done or experience convinces them otherwise, it will probably remain the treatment of choice. If your vet chooses to use the standard regimen, be aware that TBD can rebound very fast if your dog's treatment was inadequate to the purpose and only succeeded in suppressing it for a while rather than stopping it cold. Be aware, too, that if TBD does recur, it will probably be harder to control or eradicate the next time. Don't relax too soon if your dog recovers. Have regular bloodwork done and stay vigilant.

#### Considerations on giving doxycycline and other antibiotics.

Unlike other tetracyclines, doxycycline can be given with dairy products as the calcium in them doesn't affect its absorption to any appreciable degree. This means that the old standby for giving a dog pills that he doesn't want to take, cheese, is perfectly fine to wrap the capsules or tablets in. At other times, however, cheese, yogurt or any other milk product should probably be given in limited amounts to be on the safe side. There are medications, both prescription and over-the-counter, herbal preparations and minerals such as iron and zinc, which will stop doxy from working so you should be clear about this and discuss everything your dog might be taking with your vet.

Doxycycline can be irritating to the esophagus if it gets stuck on the way down so it should always be buttered, greased or hidden in something enticing. Capsules should never be broken. Since doxy comes in standardized amounts, it should be easy enough to get the correct dosage in a tablet or capsule. (For very small dogs, a compounding pharmacy may be able to help if even the smallest available dose is too much.) Give it with or after a meal. If you feed once a day, change your habits and feed your dog every twelve hours when he is due for his antibiotic if you are using the more aggressive protocol.

Antibiotics make no distinction between the beneficial bacteria that always populate your dog's gut and the harmful bacteria they are meant to eradicate. It makes sense then to do what you can to prevent any intestinal problems that might arise from those beneficial bacteria being wiped out by putting them back. Probiotics, live bacterial cultures such as *Lactobacillus acidophilus*, *Bifidus* and *Bulgaricus* which are available in capsules at health food stores, will do the trick. Give them "two hours after" every dose of doxycycline. This allows the doxycycline ample time to clear the dog's body. Any antibiotic will negate probiotics as quickly as it does the normal bacteria in the digestive tract if it is given too soon so that delay is important. Of course, this means that the next time your dog gets his usual dose of doxy you have to give him probiotics again a couple of hours later, and the cycle goes on. But it is much preferable to leaving his gut unpopulated by any helpful digestive bacteria at all until his treatment is over.

A small number of dogs cannot take doxycycline. It appears to have a serious, detrimental effect on the liver of these dogs which can be detected quickly if regular bloodwork is done while they are being treated. "The values that go awry in liver damage are chemicals in the serum," Dr. Beckett notes, "so the specific tests involved would be in a serum chemistry panel rather than in a CBC."

Because the elevated values may be due to the tick-borne disease itself rather than doxycycline, you and your vet will have to determine whether or not to stop this antibiotic and try another one. A different tetracycline, such as minocycline, might work; chloramphenicol can also be used, though with this one you must rigidly adhere to the precautions your vet will advise you about as it can be harmful, not to your dog but to you if you do not handle it with due care.

### Amoxicillin

Amoxicillin can be used as an alternative to doxycycline for Lyme disease only. Bactericidal, (destroying the cell walls of bacteria) it is not effective against any TBD other than Lyme. Amoxicillin is processed through the kidneys so it is important to know whether or not your dog has any problems with them. It will help if you have established what your dog's normal blood values are early on in his life but whether you have or not, it is advisable to keep tabs on them during treatment to be sure his kidneys are continuing to function properly.

### Imizol

Imizol (imidocarb dipropionate) is used to treat *Babesia canis* and has been used off-label to treat *E. canis* and *A. phagocytophilum*. It is given in a series of two injections two weeks apart, either under the skin (sub-Q) or in a muscle (IM). Imizol burns, so a vet would be well-advised to minimize any discomfort the dog is going to have - and he is going to have it at the moment of the shot - by drawing the drug up with one needle, then changing the needle on the syringe for a clean one that has none of the drug on its outer surface. From my own experience and that of others whose dogs have been given Imizol, the worst that happens is a very loud yowl of protest, soon over, a drippy nose or excessive drooling, restlessness and/or a large desire to lie down and go to sleep later on. Once the shot has been given, the dog should remain in or very near the vet clinic for several hours just in case he does have a serious reaction, in which case atropine sulfate is antidotal and your vet will have some on hand. I have never seen anyone on Tick List say that the antidote was necessary for their dog.

Imidocarb dipropionate does carry cautions which may prevent its administration to dogs with lung, liver or kidney problems until they are under control but your vet should be aware of this as they are plainly noted on the product label. Imizol is manufactured and sold by Schering-Plough and is now readily available in the US.

### Exposure and Infection

If your dog has a low titer for a TBD, your vet may conclude that he was only exposed to tick-borne disease and doesn't need treatment. Okay...but what does "only exposed" mean, exactly?

If the TBD organisms that are trying to invade are weak, few in number, or the innate (non-specific) immune system is in great shape and easily able to handle them, they may be stopped and wiped out before they can establish a resident population. The result is exposure without infection.

If the infective organism manages to stay in the body long enough to be noticed by the adaptive immune system, this more specific line of defense goes into gear. Identifying an invasive TBD as "not me" and dangerous, it creates antibodies to fight that particular disease, and memory cells which allow it to recognize the invader quickly if it ever encounters it again.

When antibody production starts, it tends to continue for some time whether the disease is still present and active or not. "So," according to Dr. Beckett, "as a precise generalization, when our TBD tests indicate presence of antibodies, we only have evidence, strictly speaking, that the dog's adaptive immune system has had an encounter of some sort with (i.e., has been exposed to) the antigens of the organism in question." However, he goes on to say that it is "seriously flawed thinking to rigidly equate low antibody titers with 'only exposure'. Seriously affected dogs sometimes have low titers."

Dogs with extremely high titers, on the other hand, but no symptoms or clinical signs, may be challenging infection with TBD successfully on their own. The thing to do then may be nothing, to simply wait and continue to monitor your dog. So we come back to where we began and the realization that often there are no cut and dried answers.

When tick-borne disease becomes more widely recognized for the threat it is, and efforts by dedicated research scientists to discover its secrets and create vaccines are given the funding they deserve, answers may come more readily. Until then, your best weapon against TBD is a vet

with an active and empathetic mind who will look beyond the obvious. May you all have a vet like that on your side and may no dog ever again live crippled from TBD, or die of it, for lack of one.

### **article references**

**there are many more available [here](#) or on the mirror site [here](#).**

Ehrlichiosis, a Silent and Deadly Killer: <http://home.earthlink.net/~hawkeye87/Ehrlichiosis%20Page.htm>

Canine ehrlichiosis and importance of end point-titers: Cynthia Holland, Ph.D. <http://www.protatek.com/PDF/E.canis-%20Titers.pdf>

Babesiosis in Dogs - Ron Hines, DVM, Ph.D. <http://www.2ndchance.info/babesia.htm>

John Burchard's Tick Links: <http://saluji.home.netcom.com/ticklinks.htm> From here, people can access Tick-L.

How to Build a Dry Ice Tick Trap: <http://tinyurl.com/6a7ktx>

Evaluation of Three Commercial Tick Removal Tools (Acarology Lab, Ohio State University): <http://www.biosci.ohio-state.edu/~acarolog/needham/tickgone.htm> Please use only this one if you use one at all.

Small Curved Kelly Forceps - available at <http://www.kvvet.com>, 800-423-8211 Use the search function. Next to All Products look for kelly forceps.

An Update on Anaplasmosis in Dogs: <http://tinyurl.com/6euscw>

NC State Tick Borne Diagnostic Laboratory: <http://cvm.ncsu.edu/vth/ticklab.html>

IDEXX Laboratories: <http://www.idexx.com/animalhealth/testkits/3dx/>

ProtaTek Reference Laboratory, Chandler, AZ (480) 545-8499: [http://www.protatek.com/ref\\_services.html](http://www.protatek.com/ref_services.html)

IDEXX: US Regional Map of Lyme disease, E. canis, A. phagocytophilum prevalence <http://www.dogsandticks.com/US-map-lyme-disease-dogs/index.html>

Borislav Dopudja's interesting and original article on ticks: <http://www.borislavdopudja.net/en/writings/ticks/>