WHERE DID THESE TICKS COME FROM AND NOW WHAT?

Michael W. Dryden DVM, MS, PhD, DACVM (parasitology)
University Distinguished Professor of Veterinary Parasitology
College of Veterinary Medicine
Kansas State University
Manhattan KS 66502

While often the same products are used to combat ticks as are used to combat fleas, there are substantial differences between flea and tick control. One of the major differences is in the number of species that confront a dog. While there is one predominant flea species that infests dogs in North America, the Cat flea *(Ctenocephalides felis*), there are at least 10 different tick species that may be encountered. There can be remarkable regional variability in the number and diversity of tick species that infest dogs.[1] While practitioners in Hawaii may only deal with one tick species infesting dogs (Brown Dog tick, *Rhipicephalus sanguineus*), practitioners in New Mexico may encounter three different species, in California six different species and in Kansas up to seven different tick species. This wide diversity in tick species means that ticks occur at different times of the year, are associated with different reservoir hosts and carry and transmit different diseases.

Over the past few decades there has been a change in the distribution and abundance of certain tick species in North America.[1-4] Two of the best documented are *Amblyomma americanum* and *Ixodes scapularis*.[2-4] Since both these ticks are important vectors of human and animal pathogens these changes in distribution and abundance have had a marked effect upon both human and animal health. Various factors have contributed to tick population movement including; changes in agricultural practices, reforestation, wildlife conservation, relocation and restocking, climate fluctuations and decreased environmental pesticide application.[5,6]

Specific factors that have contributed to the increased range of *A. americanum* include increased habitat via reforestation and its wide host range that includes deer, small mammals, birds and man[3,4]. The White-Tailed Deer is considered a preferred host for *A. americanum*, and all life stages will feed successfully upon White-Tailed Deer. Another species that utilizes similar habitats and is an excellent host for larvae and nymphs is the wild turkey. Areas with high White-Tailed Deer and wild turkey populations can have remarkably large populations of *A. americanum.* Similar to *A. americanum* the distribution of *I. scapularis* is linked to the distribution and abundance of the white-tailed deer.[2]

Ixodes scapularis is widely distributed in the Eastern and Central U.S. in at least 35 states.[5,6] Its distribution is from Florida to Maine, west into far eastern South Dakota, and south through eastern Kansas into central Texas.

*Ixodes scapularis i*s also located in central and eastern Canada. *Ixodes scapularis* populations between 2004 and 2008 increased exponentially from around 600 per year to more than 1,700 submissions per year.[7] In a later study the number of confirmed Lyme disease-endemic areas in southern parts of Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia increased from 10 in 2009 to 22 confirmed endemic areas in 2012.[8] Field surveillance data indicated that there was a tenfold increase in the numbers of I. *scapularis* reported from passive surveillance from 2,059 submissions from between 1990 to 2003 to 25,738 submissions from 2004 to 2012.[8] While white-tailed deer and small rodents clearly been instrumental in tick and Lyme expansion, the role of small migratory birds has been historically under appreciated.

Between 2005 and 2006, 39,095 northward-migrating land birds were captured in eastern Canada. Prevalence of birds carrying *I. scapularis* (mostly nymphs) was 2.2%. Overall, 15.4% of I. scapularis nymphs were PCR positive for *Borrelia burgdorferi*. It was estimated that migratory birds disperse 50 to 175 million *I. scapularis* ticks across Canada each spring.[9]

Seasonal activity varies by geographic region, but larval activity is generally highest in August and September. Larvae attach to and feed on a wide variety of small mammals, including mice, chipmunks and shrews. Larvae also feed on birds and lizards. The white-footed mouse (*Peromyscus leucopus*) is of particular importance in the tick life cycle and disease transmission, because it serves as a good host for larval *I. scapularis* and it is a major reservoir of *Borrelia burgdorferi*.

Immature ticks typically engorge for 2 to 4 days before dropping off to molt in moist protected areas such as under leaf litter in forested habitats. Larvae over-winter and then molt to nymphs in the spring. Nymphs will feed for 3 – 4 days on a variety of hosts including mice, squirrels, chipmunks, raccoons, opossums, skunks, shrews, cats, birds, and humans. Nymphs occur primarily from May through July in the North. Adults occur most commonly from October through December. Adults that do not find a host will quest again, typically from March to May. Adults feed for 5 – 7 days, primarily on white-tailed deer, but also on bobcats, cattle, coyotes, dogs, foxes, horses, humans, opossums, raccoons and other mammals.

While recent pharmaceutical advances have been made in control of flea reproduction, such advances in the area of tick control are lacking. With the exception of the brown dog tick *Rhipicephalus sanguineus*, our ability to manage tick reproduction is limited, if not almost non-existent. As discussed previously in most flea infestations we have the opportunity to control flea reproduction by either killing fleas before they can reproduce or killing flea eggs. However, it is not just because we have effective residual insecticides, insect growth regulators or insect development inhibitors that we are successful, it is also due in large part to the fact we can often target the primary reproductive host, the flea infested dog or cat. And interestingly, failures in flea control often occur when flea infested feral pets or flea infested urban wildlife invade the owners' yards.

But when dealing with most 3-host ticks the problem is that the majority of the reproducing ticks are not on the dogs or cats, but on their nature wildlife hosts. Since we are limited in our ability to manage ticks on wildlife, reinfestations are a common occurrence and protracted use of acaracides as preventives is routine in many areas.

Since tick control can be extremely difficult and because they are vectors of a variety of bacterial and protozoal diseases veterinarians should have an understanding of the ecology of the tick(s) encountered in the area in which they practice. Veterinarians need to be educated on the various aspects of tick ecology, disease transmission and control methodologies so that they can then educate their staff and pet owners.

Numerous studies demonstrate the high level of efficacy of the various acaracides, but the residual activity is rarely 100% and the efficacy of products varies between and as well as within species, even in the same laboraotry.[10-23] Evaluations of acaracides under natural or field conditions further illustrates that while efficacy is good it is not always 100%.

In a field efficacy trial conducted in Kansas U.S.A, an imidacloprid (8.8% w/w)-permethrin (44.0% w/w) formulation was evaluated on dogs against naturally occurring populations of *Amblyomma americanum*. When dogs were walked in a naturally tick infested environment the 48-hour post-exposure efficacy of imidacloprid-permethrin formulation was 93.5%, 98.9%, 94.6%, 94.1% and 96.6% on days 3, 7, 14, 21 and 28 respectively, post-treatment.[16]

Variation in product efficacy occurs. In two studies conducted at K-State, different results were found when evaluating the efficacy of acaricides against Dermacentor variabilis infestations in dogs from two different regions of the USA.[13,16] In the first study, the efficacy of imidacloprid–permethrin and fipronil–(s)-methoprene formulations were evaluated against a D. variabilis isolate from California. The 48-h post-infestation efficacy on day 30 post-treatment was 92.0% and 83.2%, respectively, for the imidacloprid–permethrin and fipronil–(s)-methoprene formulations. In the second study, the 48-h post-infestation efficacy on day 30 for the imidacloprid–permethrin and fipronil–(s)-methoprene formulations against a *D. variabilis* isolate from Oklahoma was17.5% and 75.7% respectively.

Recently a new class of insecticide/acaracide has provided the first orally administered approach to tick control. Afoxolaner, fluralaner, lotilaner and sarolaner are members of the isoxazoline class and work by inhibiting insect GABA and Glutamate-gated chloride channels leading to hyper-excitation and death of insects and arachnids.[18-23]

While product efficacy is often excellent in most studies, significant variation in efficacy can occur and 100% control is rarely achieved. Therefore, it can be expected that under natural conditions in areas where dogs are being frequently exposed to ticks, pet owners will see ticks on treated dogs. We might also expect that efficacy in real world situations might be lower due to such factors as bathing and swimming, differences between dog breeds and haircoat types and frequency and correctness of product application.

Since 100% tick kill is rarely achievable, perceived efficacy of acaracides may be directly related to the numbers of ticks to which dogs are exposed. If a dog is treated with one of these highly efficacious acaracides and encounters just a few ticks it is likely all those ticks will be killed. However, if tick exposure is considerably larger, we can expect a few ticks to be observed on these dogs and pet owners may perceive a lack of efficacy. Therefore, in areas where tick populations are increasing the perception may be that the products are not as effective as they once were.

Pet owners often view tick infestations of their pets differently than flea infestations.[12] Whether this is due to concerns about tick transmitted diseases or simply a phobia, the presence of a couple of ticks on the pet often elicits a more pronounced negative reaction than the presence of a couple of fleas. A 95% effective flea product may provide great client satisfaction while a similarly effective tick product may be perceived as a failure. Therefore, it is not uncommon that label recommended application of a product does not appear to control the problem. This may be real or perceived, based upon pet owner expectations of product performance. Given pet owner concerns, a need to reduce tick borne disease and lack of 100% efficacy; occasionally additional control measures are needed. If additional control measures are deemed necessary, pet owners need to be educated as to why additional control measures are necessary and notations made in the pets record before extra label uses are conducted.

One of the most common practical attempted solutions to this problem in dogs is to increase the frequency of application. Here increased residual efficacy is the expected outcome, since you are increasing the residual acaracides levels with the shorter application intervals. Additionally, with many 3-host ticks destruction of tick habitat can reduce exposure pressure. Areas that serve as refuge for ticks and wild mammals such as grass, weeds, and brush piles, between runs and along buildings, can be eliminated or treated with an approved acaricide.

In some situations, especially in tropical and subtropical regions and in climate controlled kennels brown dog ticks may infest buildings with ticks crawling up walls, curtains and throughout the home or kennel. In these situations acaracides may need to be sprayed indoors into cracks and crevices, behind and under furniture or cages and along walls and the ceiling. Following

application, make sure the acaricide is dry before you allow animals or humans back into the premises to minimize toxicity problems. Finally, restricting pet access from tick-infested environments may be necessary.

It is apparent that the range and local density of certain tick species has increased in many areas. Whatever the factors it must be recognized that tick infestation pressure may be much higher and associated tick transmitted diseases may be more prevalent in some locations today than in the past. The increase in tick populations means that pets are encountering ticks more frequently, are exposed to more ticks per encounter and clients may be seeing more ticks on their pets than in the past. Since tick products do not kill or repel all ticks instantly, clients may get the false impression that the products are not performing as well as in the past. These situations necessitate that veterinarians set client expectations, before clients set their own unrealistic expectations of control.

References

1. Dryden MW, Payne PA. Biology and Control of ticks infesting dogs and cats in North America. *Vet Ther* 2004; 26:2-16.
2. Estrada-Pena A. Increasing habitat suitability in the United States for the tick that transmits Lyme disease: A remote sensing approach. *Environ Health Perspectives* 2002; 110:635-40.
3. Childs JE, Paddock CD. The ascendancy of *Amblyomma americanum* as a vector of pathogens affecting humans in the United States. *Ann Review Entomol* 2003; 48:307-37.
4. Paddock CD, Yabsley MJ. Ecological havoc, the rise of white-tailed deer and the emergence of *Amblyomma americanum*-associated zoonoses in the United States. *Curr Top Microbiol Immunol* 2007; 315:289-324.
5. Keirans JE, Hutcheson HJ, Durden LA, et al. *Ixodes* (Ixodes) *scapularis* (Acari:Ixodidae): redescription of all active stages, distribution, hosts, geographical variation, and medical and veterinary importance. *J Med Entomol* 1996; 33: 297-318.
6. Dennis DT, Nekomoto TS, Victor JC, et al. Reported distribution of *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae) in the United States. *J Med Entomol* 1998; 35(5):629-38.
7. Ogden NH et. al. Active and Passive Surveillance and Phylogenetic Analysis of Borrelia burgdorferi Elucidate the Process of Lyme Disease Risk Emergence in Canada. Environ Health Perspect 118:909-914 (2010)
8. Ogden NH et al. Environmental risk from Lyme disease in central and eastern Canada: a summary of recent surveillance information. Canada Communicable Dis. Report. 40(5):74-82, 2014
9. N. H. Ogden. Role of Migratory Birds in Introduction and Range Expansion of Ixodes scapularis Ticks and of Borrelia burgdorferi and Anaplasma phagocytophilum in Canada APPLIED AND ENVIRONMENTAL MICROBIOLOGY, 2008, 74:1780–1790
10. Dryden MW, Payne PA, Smith V, et al. Evaluation of an imidacloprid (8.8% w/w)--permethrin (44.0% w/w) topical spot-on and a fipronil (9.8% w/w)--(S)-methoprene (8.8% w/w) topical spot-on to repel, prevent attachment, and kill adult *Rhipicephalus sanguineus* and *Dermacentor variabilis* ticks on dogs. *Vet Ther* 2006; 7(3):187-98.
11. Dryden MW, Payne PA, Smith V, et al. Evaluation of an imidacloprid (8.8% w/w)--permethrin (44.0% w/w) topical spot-on and a fipronil (9.8% w/w)--(S)-methoprene (8.8%

w/w) topical spot-on to repel, prevent attachment, and kill adult *Ixodes scapularis* and *Amblyomma americanum* ticks on dogs. *Vet Ther* 2006; 7(3):173-86.
12. Rugg D, Hair JA. Dose determination of a novel formulation of metaflumizone plus amitraz for control of cat fleas (Ctenocephalides felis felis) and brown dog ticks (*Rhipicephalus sanguineus*) on dogs. *Vet Parasitol* 2007; 150:203-8.
13. Dryden M, Payne P, McBride A, et al. Efficacy of Fipronil (9.8% w/w) + (S)-Methoprene (8.8% w/w) and Imidacloprid (8.8% w/w) + Permethrin (44% w/w) against *Dermacentor variabilis* (American Dog Tick) on Dogs. *Vet Ther* 2008; 9(1):15-25.
14. Dryden MW, Smith V, Kunkle B, Carithers D. A Study to Evaluate the Acaricidal Efficacy of a Single Topical Treatment with a Topical Combination of Fipronil/Amitraz/(S)-Methoprene Against *Dermacentor Variabilis* on Dogs. *Intern J Appl Res Vet Med* 2012; 10(2):125-31.
15. Doyle V, Beugnet F, Carithers D. Comparative efficacy of the combination fipronil-(S)-methoprene and the combination permethrin-imidacloprid against *Dermacentor reticulatus*, the European dog tick, applied topically to dogs. *Vet Ther* 2005; 6:303-10.
16. Dryden MW, Payne PA, Smith V, Hostetler J. Efficacy of imidacloprid (8.8% w/w) plus permethrin (44% w/w) spot-on topical solution against *Amblyomma americanum* infesting dogs using a natural tick exposure model. *Vet Ther* 2006; 7:99-106.
17. Estrada-Peña A, Rème C. Efficacy of a collar impregnated with amitraz and pyriproxyfen for prevention of experimental tick infestations by *Rhipicephalus sanguineus*, *Ixodes ricinus*, and *Ixodes scapularis* in dogs. *JAVMA* 2005; 15:221-4.
18. Rohdich N, Roepke RK, Zschiesche E. A randomized, blinded, controlled and multi-centered field study comparing the efficacy and safety of Bravecto (fluralaner) against Frontline (fipronil) in flea- and tick-infested dogs. *Parasit Vectors* 2014; 7:83.
19. Mitchell EB, McCall JW, Theodore Chester S, Larsen D. Efficacy of afoxolaner against Ixodes scapularis ticks in dogs. *Vet Parasitol* 2014; 201(3-4):223-5.
20. Mitchell EB, Dorr P, Everett WR, Chester TS, Larsen D.Efficacy of afoxolaner against Dermacentor variabilis ticks in dogs. *Vet Parasitol* 2014; 201(3-4):220-2.
21. Becskei C, Geurden T, Liebenberg J, Cuppens O, Mahabir SP, Six RH. Comparative speed of kill of oral treatments with Simparica™ (sarolaner) and Bravecto®(fluralaner) against induced infestations of Rhipicephalus sanguineus on dogs. Parasit Vectors. 2016 Feb 24;9:103
22. Six RH, Young DR, Myers MR, Mahabir SP.Comparative speed of kill of sarolaner (Simparica™ Chewables) and fluralaner (Bravecto(®)) against induced infestations of Amblyomma americanum on dogs. Parasit Vectors. 2016 Jul 18;9(1):399
23. Murphy M, Garcia R, Karadzovska D, Cavalleri D, Snyder D, Seewald W, Real T, Drake J, Wiseman S, Nanchen S.Laboratory evaluations of the immediate and sustained efficacy of lotilaner (Credelio™) against four common species of ticks affecting dogs in North America. Parasit Vectors. 2017 Nov 1;10(1):523