Ticks (Acari: Ixodidae) Parasitizing Canines and Deer in Arkansas[1]

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Abstract Increased occurrence of tick-borne diseases requires the surveillance of tick species associated with humans and the animals they contact. Tick species were collected from canines and deer throughout Arkansas by veterinarians during December 2006 to October 2007, while personnel with the Arkansas Game and Fish Commission collected ticks from hunter-killed deer throughout the 2007 hunting season (Oct-Dec). Five tick species were collected: *Ixodes scapularis* Say (51%), *Amblyomma americanum* (L.) (22%), *Rhipicephalus sanguineus* (Latreille) (12%), *A. maculatum* (Koch) (7%), *Dermacentor variabilis* (Say) (6%), and unidentified *Amblyomma* species (2%). Tick collections from canines were *A. americanum* (45%), whereas 89% of ticks collected from deer were *I. scapularis*. These 2 tick species also were found simultaneously infesting the same canine and deer hosts. Our data identify 5 tick species and update the current distribution of each species that may be involved in the Arkansas tick-borne disease cycle.

Key Words Ixodidae, Arkansas, canines, deer, *Amblyomma*, *Ixodes*

Tick-borne pathogens are common worldwide, but Arkansas's habitat provides more than 13 million hectares of land with ideal habitat for wildlife, ticks, and multiple pathogens (ARDH 1995). Recent human demographic changes have occurred in Arkansas, including a 14% gain in the state's population from 1990 - 2000, with a majority of the gain occurring in northwest Arkansas (Anonymous 2001). The northwest Arkansas region of Benton and Washington counties has become one of the nation's top-ten fastest growing metropolitan areas, accounting for more than 47% population growth (Anonymous 2001). Consequently, many traditionally rural and agricultural areas have been urbanized. The resulting human encroachment into these habitats has increased the likelihood for ticks to move from wild animals to humans and domesticated animals. The aforementioned demographic changes combined with transovarial and transstadial transmission capability among the tick-pathogens have lead to an increase in the incidence of tick-borne illnesses reported in urban areas of Arkansas (ARDH 1995). Tick-borne diseases are reported in all areas of Arkansas, and a majority of cases occurs in young children during spring and early summer (ARDH 1997).

Little information was available relative to tick-host interactions in Arkansas. Previous reports of tick presence on Arkansas canines indicated that *Rhipicephalus sanguineus* (Latreille) was the most abundant tick, followed by *Amblyomma americanum* (L.), *Dermacentor variabilis* (Say) and *Ixodes scapularis* Say (Koch 1982). A majority

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of these canines were infested simultaneously by at least 2 tick species (Koch 1982). Reports in Arkansas have been focused on state parks (Eads 2001), the area around Fayetteville (Lancaster 1955, 1957), or the few ticks submitted by health departments and physicians to larger studies (McCall et al. 2001, Stromdahl et al. 2003). Tugwell and Lancaster (1962) reported *I. scapularis* from 4 deer, and 16 other bird and mammal hosts in Arkansas. In North Carolina, both *I. scapularis* and *A. americanum* were found infesting deer (Apperson et al. 1990). In Oklahoma, *Amblyomma maculatum* (Koch) was collected from both wild and domestic mammals (Barker et al. 2004) and found in 18 eastern counties (Semtner and Hair 1973). However, few reports have identified this tick in Arkansas (Lancaster 1973, Eads 2001). Additionally, information relative to tick species found on deer does not exist for Arkansas.

A recent 40-state study (Raghavan et al. 2007) ranked Arkansas second highest in the level of tick-infested canines. Interestingly, of the 6 states bordering Arkansas, Oklahoma (#1) and Tennessee (#9), were ranked in the top-ten in tick-infested canines (Raghavan et al. 2007). Although their paper was comprised of several years of data, the study did not identify the ticks, or their subsequent seasonal distribution thoroughly (Raghavan et al. 2007).

It is important to have a current record of the tick fauna associated with different hosts to monitor introductions of new species and to monitor the risk for pathogen transmission associated with each tick species. Reports indicate that ticks associated with canines may play a role with human *Rickettsia rickettsii* infections (Sexton et al. 1976, Lancaster and Patrick 1977), and ticks associated with deer are correlated with *Borrelia burgdorferi* transmission (Fish 1995). Lyme disease risk has been correlated with exposure to *I. scapularis* on deer and exposure to tick-infested canines (Daniels et al. 1993). Here we report the identification of ticks and their distribution as associated with canines (*Canis lupus domesticus* L.) and deer (*Odocoileus virginianus* Zimmermann) hosts in Arkansas.

Materials and Methods

We assembled and mailed collection kits that included collection and mailing instructions as well as vials containing 100% ethanol to 250 practicing veterinarians across the state. Once a clinic participated in the study, the clinic received another collection kit so the same clinic was solicited more than once, totaling 323 kits distributed across the state. Additionally, collection kits were assembled and distributed to the Arkansas Game and Fish Commission to collect ticks from hunter-killed deer that were examined for Chronic Wasting Disease (a separate study). Ticks were collected from March 2006 to January 2008, and collections came from the state of Arkansas and portions of the Ozarks, which extend into Oklahoma and Missouri. Collectors removed ticks from the host, stored them in vials containing 100% ethanol, and recorded tick collection date, location, and host. Collections were mailed to the Veterinary Entomology Laboratory at the University of Arkansas where they were identified to species, sex, and life stage (Arthur 1961, Lancaster 1973, Goddard and Norment 1985).

Results and Discussion

A total of 3,259 ticks was collected from canines, deer, and a few felines. Five tick species were collected from the hosts during the 2006 - 2007 study (Table 1). The majority (53%) of the ticks collected were from 233 infested deer compared with 156

Table 1. Identified Ixodidae tick species and life stage* collected from Arkansas canines and deer.

	Canine						Deer				
Species	L	N	M	F	A	Total	L	N	M	F	Total
Amblyomma spp.**	16	15	11	7	8	57	.	.	.	.	.
Amblyomma americanum	0	162	236	234	.	632	0	3	11	18	32
Amblyomma maculatum	0	8	95	9	1	113	0	8	46	41	95
Dermacentor variabilis	1	41	52	84	.	178	0	2	2	2	6
Ixodes scapularis	0	6	43	72	.	121	1	14	492	887	1515
Rhipicephalus sanguineus	0	97	94	123	.	314	0	0	13	29	42
Total	17	329	531	529	9	1415	1	27	564	977	1690

*Number of larva (L), nymph (N), adult male (M), adult female (F), and adult specimen was damaged and could not be properly sexed (A).
**Indicates specimens were damaged and could not be properly identified to species.

infested canines. *Ixodes scapularis* (53%) and *Amblyomma americanum* (21%) were the most common ticks. Previously, these ticks were reported on both mammals and birds within Arkansas (Tugwell and Lancaster 1962). Seasonal occurrence of these tick species during the sampling period on both canines (Fig. 1) and deer (Fig. 2) included *A. americanum* collections in the late spring/early summer on dogs and *I. scapularis* collections late in the year. The geographic distribution and number of each tick species in Arkansas are presented in Fig. 3.

Tick collections from canines. We received collections from 35 of the 250 solicited Arkansas veterinary clinics (14% participation). Participating clinics were primarily located in northwest Arkansas; however, we obtained samples from 27 counties throughout the state. Collections from canines were received from December 2006 to November 2007 (Fig. 1). A total of 1415 ticks was collected from 156 canines, with a majority of the ticks collected in March (17%), April (15%), June (14%), and July (16%). There was a mean of 8.2 (± 0.2 SE) ticks collected per host (ranging from 1 tick to 100 ticks, median of 5 ticks per host). Most of the ticks collected from canines were *A. americanum* (44.7%), and the majority of collections reflected this species with its occurrence between April and July 2007 (Fig. 1). Although there was a decrease in tick numbers occurring on dogs in May, this may have been due to fewer canines being sampled at that time rather than a lack of canine infestation. This thought was supported by the finding that "the highest adjusted cumulative monthly tick prevalence was observed in April and May from 493 dogs with ticks per 10,000 dog visits in Arkansas" (Raghavan et al. 2007). Additionally, the large number of *A. americanum* in

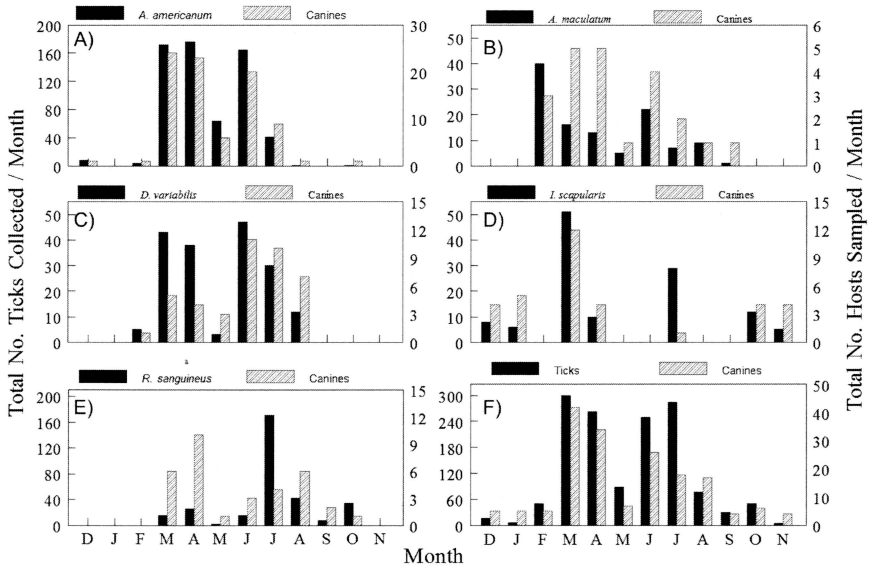

Fig. 1. Total monthly numbers of A) *A. americanum*, B) *A. maculatum*, C) *D. variabilis*, D) *I. scapularis*, E) *R. sanguineus* and F) total number of ticks collected from canines compared with the monthly total number of infested canines (Dec 2006-Nov 2007).

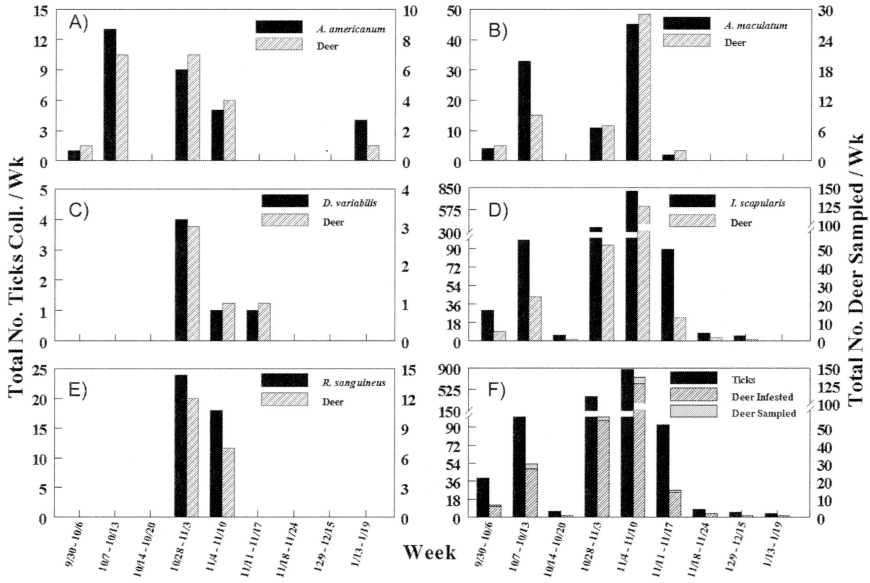

Fig. 2. Total weekly counts of A) *A. americanum*, B) *A. maculatum*, C) *D. variabilis*, D) *I. scapularis*, E) *R. sanguineus* and F) total number of ticks collected from deer compared with the weekly total number of infested deer (Oct 2007-Jan 2008).

the late spring and early summer was suggested in Koch's study (1982). Our findings were similar to previous reports on *A. americanum* seasonality, which identified active adults from April to July with a peak in June, active nymphs from April through September with bimodal peaks in April/May and in August, and active larvae from April through July peaking in June (Lancaster 1955, 1957, Tugwell and Lancaster 1963, Goddard 2007). When *A. americanum* reaches peak activity (spring and summer), the peak incidence of tick-borne diseases in Arkansas also occurs (ARDH 1997).

A recent study in Georgia identified *D. variabilis* and *R. sanguineus* as the primary tick species infesting canines, while *A. americanum* was the third most prevalent tick (Goldberg et al. 2002). Previous research on Arkansas ticks collected from canines identified *R. sanguineus* as the most abundant tick species (Koch 1982). Koch's study preceded the large influx of people to the state, and that study focused on southeastern Oklahoma and northwest Arkansas over 20 yr ago. Our findings suggest canine infestation with *A. americanum* may be more severe in Arkansas than previously expected because our survey included most of the state.

In addition to collections from canines, veterinarians also collected ticks from 16 felines. From these hosts, 154 ticks were collected representing all 5 tick species found on the canines: *A. americanum* (36%), *D. variabilis* (19%), *R. sanguineus* (14%), *A. maculatum* (1%), and *I. scapularis* (1%). An additional 2.9% were *Amblyomma* ticks, but they could not be sexed or identified to species because the specimens were damaged. The seasonal occurrence of these ticks found on felines was similar to those found on canines, with a majority of the ticks being collected late spring to early summer.

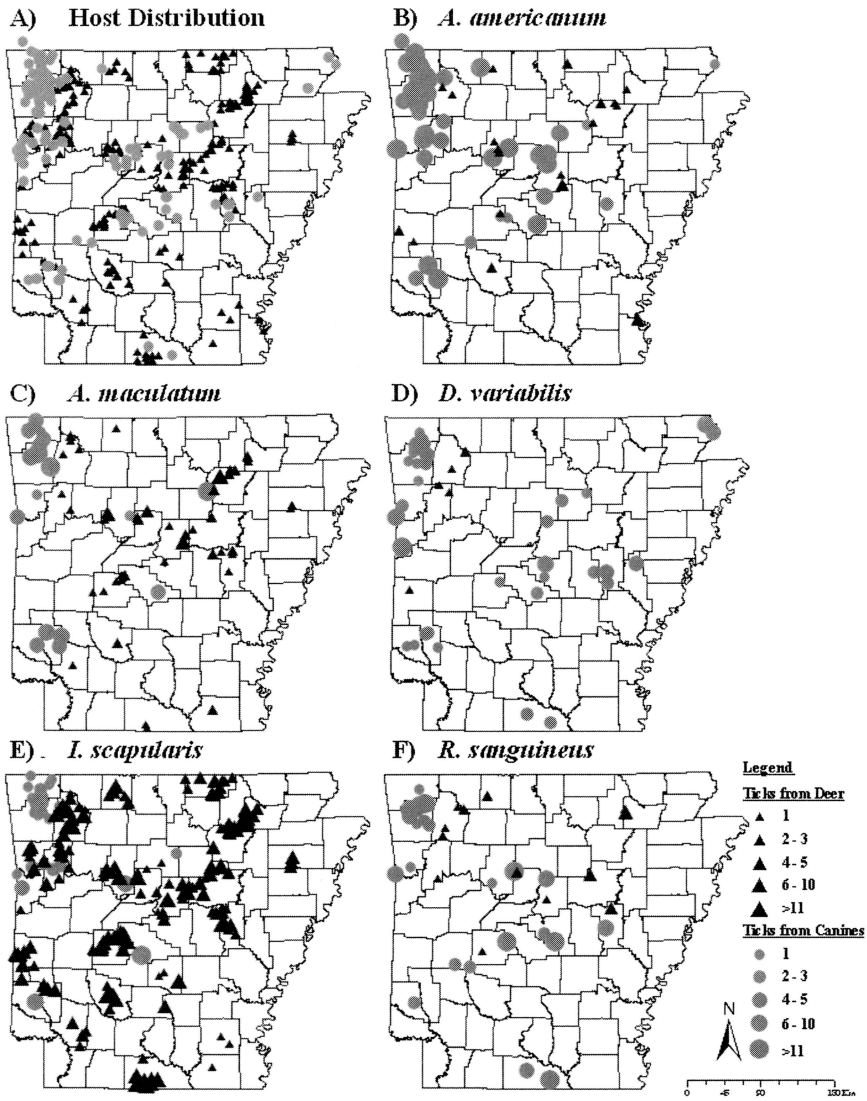

Fig. 3. Geographical distribution and abundance of A) sampled hosts, B) *A. americanum*, C) *A. maculatum*, D) *D. variabilis*, E) *I. scapularis*, and F) *R. sanguineus* collected from canines and deer in Arkansas. (Dark triangles represent collections from deer, whereas lighter circles represent collections from canines; the larger the symbol the greater the abundance of ticks from that specific host.)

Tick collections from deer. During the 2008 hunting season, 1569 ticks were collected from 250 deer throughout the state. Because collections were made during Arkansas's annual Chronic Wasting Disease sampling, all deer with zero ticks were

still counted as not infested (17 deer not infested), even though there may have been ticks hidden deep within the animal's hair. A majority of the ticks collected from deer were *I. scapularis* (89.6%), whereas less than 1% of the ticks from deer were *D. variabilis* (Fig. 2). There was a mean of 6.3 (±0.4 SE) ticks collected per host (ranging from 0 ticks to 32 ticks). Five tick species were encountered (Table 1, Fig. 2) and some deer were sampled for ticks, but deer keds (*Lipoptena mazamae* Rondani) were collected instead. The bimodal peaks in the number of ticks collected and the number of deer investigated may have been due to Arkansas's hunting season. The first peak correlated with muzzleloader season, whereas the second peak correlated with modern gun season. Our finding that *I. scapularis* was the most prevalent tick on deer concurred with previous studies identifying *I. scapularis* infesting deer in northwest Arkansas (Tugwell and Lancaster 1962) and both *I. scapularis* and *A. americanum* as the 2 dominant tick species infesting North Carolina deer (Apperson et al. 1990). Contrary to our findings, the most-common tick infesting exotic deer and white-tailed deer in Texas was *A. americanum*, although *D. albopictus* and *I. scapularis* also were encountered (Richardson and Demarais 1992). Richardson and Demarais' (1992) study was over a 2-yr period with a majority of *A. americanum* collected in the spring and summer. We did not sample ticks from deer during the spring and summer so our numbers of *A. americanum* on deer may be fewer than expected.

Simultaneous infestations of tick species. Hosts parasitized by more than one tick species were not common among canines (23%) or deer (30%) (Table 2). Of the canine hosts sampled, 26 dogs had 2 tick species, 9 dogs had 3 tick species, and 1 dog had 4 tick species (2 *A. americanum*, 2 *R. sanguineus*, 1 *D. variabilis,* and 1 *I. scapularis*). Deer collections included 66 hosts with 2 tick species and 9 hosts with 3 tick species. All of the deer simultaneously infested included *I. scapularis* (100%), whereas 93% of canines simultaneously infested included *A. americanum.* Simultaneous infestations of *A. americanum* and *I. scapularis* may identify a point of potential pathogen transmission from one tick species to another species and to different hosts (Koch 1982). Apperson et al. (1990) also found that simultaneous infestations of these 2 tick species were common on white-tailed deer in North Carolina. The exposure to tick-infested canines and *I. scapularis*-infested deer has shown to increase the risk of *B. burgdorferi* transmission (Daniels et al. 1993). Additionally, the finding of *I. scapularis* and *D. variabilis* cofeeding together is a concern because this may lead to increased infection rates of *D. variabilis* (Piesman and Happ 1977).

The present study identified *I. scapularis* and *A. americanum* as the most frequently found tick species in Arkansas. A change occurred in the tick fauna associated with canines and deer from Koch's study to the present study. We observed the more northern establishment of *A. maculatum* and the greater expansion of *A. americanum* and *I. scapularis* across the state (Fig. 3). In contrast to our study, in northwest Georgia *D. variabilis* was the most prevalent tick species infesting canines (Goldberg et al. 2002).

Simultaneous infestations of hosts by *I. scapularis* and *A. americanum* are a concern for pathogen transmission. *Ixodes scapularis* is a significant public health concern because it is the vector of *Borrelia burgdorferi*, which is the causative agent of Lyme disease in the United States (Piesman and Sinsky 1988, Oliver et al. 1993, Piesman 1993, Qiu et al. 2002). Additionally, *A. americanum* has been identified as the vector of *Ehrlichia chaffeensis* (Stromdahl et al. 2000, Whitlock et al. 2000, Long et al. 2004); this tick also may vector *Borrelia lonestari* (Bacon et al. 2003, Stromdahl et al. 2003) and may vector several *Rickettsia* species (Goddard and Norment 1986, Childs and Paddock 2003, Apperson et al. 2008). Investigations into *A. americanum*

Table 2. Single, dual, and multiple infestations of tick species* on canines and deer.**

No. Hosts Infested by Indicated Tick Species										
					Single Species Infestation					
Host	Total		A		M	D		I		R
Canine	115		43		7	19		25		21
Deer	158		2		6	0		148		2
Total	273		45		13	19		173		23
					Dual Species Infestation					
Host	Total	AM	AD	AI	AR	MD	MI	MR	DI	IR
Canine	29	4	12	4	7	1	0	1	0	0
Deer	66	0	0	12	0	0	38	0	4	12
Total	95	4	12	16	7	1	38	1	4	12
					Multiple Species Infestation					
Host	Total	AMD	AMI	ADR	AIR	MIR	DIR	ADIR		
Canine	12	5	3	3	0	0	0	1		
Deer	9	0	4	0	2	2	1	0		
Total	21	5	7	3	2	2	1	1		

* A = *Amblyomma americanum;* M = *Amblyomma maculatum;* D = *Dermacentor variabilis;* I = *Ixodes scapularis;* R = *Rhipicephalus sanguineus.*

**There were 17 deer sampled that did not have any ticks, and 19 canines sampled with damaged ticks that could not be properly identified to species.

transmission of *E. chaffeensis*, *E. ewingii*, and *B. lonestari* to deer has been demonstrated with PCR, sero tests, and cell culture (Varela-Stokes 2007). The need for study to determine the vector capacity and competence of *A. americanum* continues as the likelihood of vector competence with transmission and incidence in the south is high (Childs and Paddock 2003).

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