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The Ticks (Arachnida: Acari: Ixodida) of Arkansas

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Running Title: Ticks of Arkansas

Abstract

Although ticks are a nuisance to humans and other animals, they are an important part of the biota of North America. In addition, they are vectors of many tick-borne disease agents that can negatively affect higher vertebrates. In Arkansas, there have been no recent comprehensive summaries of the ticks (Acari: Ixodida) in the last 40+ yrs. Here, we provide a summary of the ticks of the state and note the disease agents they can transmit.

Introduction

Ticks are ectoparasites that feed on the blood of various vertebrates, mainly birds and mammals, but some species parasitize amphibians and reptiles. They also serve as vectors of several tick-borne disease agents that affect humans and other vertebrates. The importance of ticks as vectors of pathogens in Arkansas has been highlighted previously (Anonymous 1995). In 2010, Arkansas ranked first among U.S. states for reported cases of tularemia (caused by *Francisella tularensis*), fourth for Rocky Mountain spotted fever (RMSF) (caused by *Rickettsia rickettsii*), and tenth in reported cases of Human Monocytic Ehrlichiosis (HME) (caused by *Ehrlichia chaffeensis*) (CDC 2010). Kardatke et al. (1992) documented a cluster of zoonotic pathogens [Spotted Fever Group Rickettsiae (SFGR), ehrlichiae and *Borrelia burgdorferi*] detected in ticks at Fort Chaffee, Arkansas. However, Trout-Fryxell et al. (2015) molecularly detected SFGR in 5 species of ticks from Arkansas and identified *Rickettsia montanensis* and *candidatus* *Rickettsia amblyommii* but not *R. rickettsia*, suggesting that some Arkansas cases diagnosed as RMSF may actually represent infections with other rickettsial agents. Tick paralysis can be caused by the release of certain salivary components by attached ticks (usually females) of some Arkansas

ticks, especially *Dermacentor variabilis* but also (rarely) by *Otobius megnini*, *Amblyomma americanum*, *Amblyomma maculatum*, *Dermacentor albipictus*, *Ixodes scapularis* and *Rhipicephalus sanguineus* (Strickland et al. 1976, Durden and Mans 2016). Despite the medical and veterinary importance of ticks in Arkansas, some species may play an important biological role by promoting genetic diversity in host populations, regulating host population densities (either directly or indirectly by transmitting pathogens) and preventing overgrazing of plant resources (Durden and Keirans 1996a).

In Arkansas, Lancaster (1957a) was the first to produce a monograph on the ticks of the state. Later, Tugwell and Lancaster (1962, 1963) documented the hosts and seasonality of ticks in northwestern Arkansas. Lancaster (1973) provided detailed information of the ticks of Arkansas which included 18 species occurring in the state. Later, Ellis (1975) provided a synopsis of common Arkansas ticks and Lancaster (1979) provided a checklist of Arkansas ticks. Trout and Steelman (2010) surveyed 5 species of ticks parasitizing canines and/or deer in Arkansas (*A. americanum*, *A. maculatum*, *D. variabilis*, *I. scapularis* and *R. sanguineus*) and documented their seasonalities and distributions in the state. McAllister et al. (2013) reported on some ticks from sciurid rodents of the state, and Tumilson et al. (2015) provided records of ticks from several rodents. However, for more than 40 yrs (Lancaster 1973), there have been no attempt to provide a comprehensive list of Arkansas ticks.

The purpose of this report is three-fold: (1) update the ticks that currently occur in Arkansas including records of ticks accessioned into the United States National Tick Collection (USNTC) which is on long term enhancement loan to Georgia Southern University (GSU), (2) provide the most recent taxonomy on these ticks, and (3) note the species of ticks that are vectors for disease agents. Lancaster (1973) provided excellent diagnostic line drawings and illustrations for

the 18 species of ticks he recorded from Arkansas. Diagnostic illustrations for an additional species (*Ixodes woodi*) we record here from the state can be found in Keirans and Clifford (1978) and Durden and Keirans (1996).

Methods

We conducted an exhaustive search of the scientific literature for information on Arkansas ticks. In addition, collection data on tick specimens deposited or recorded in the USNTC were examined. In the lists that follow, the following abbreviations are used:

A = Adult tick(s) (sexes were not determined for some older tick specimens deposited in the USNTC).

M = Male(s).

F = Female(s)

N = Nymph(s)

L = Larva(e)

*Collector (WJB = WJ Baerg SJ= SJ Carpenter; JLL=JL Lancaster; DAS = D.A. Saugay; FCW = FC Wonder)

RML (followed by a number) = accession number in the USNTC for the reported specimen(s).

All Arkansas tick specimens in the USNTC were examined; however, some older specimens had been returned to the submitters so the exact number of males, females or immatures in each collection could not always be determined. Common tick names listed follow the Common Names of Insects Database (Entomological Society of America 2016).

Results

We report a total of 3 argasid (soft tick) species and 16 ixodid (hard tick) species from 35 of 75 (47%) counties of Arkansas (Fig. 1). One of these, *I. woodi*, is reported from the state for the first time. Another species, *Rhipicephalus (Boophilus) annulatus*, has been extirpated from Arkansas, whereas an additional species, *Amblyomma maculatum* (Gulf Coast tick), has been expanding its range into this state. In addition to the species reported here, humans (or pets) returning to Arkansas from other parts of North America or the world could bring back attached non-native tick species.

Family Argasidae (soft ticks)

***Carios (Ornithodoros) kelleyi* (Dugés) – no common name.** A single specimen was reported by Lancaster (1973) in Stone County from a pigeon (more

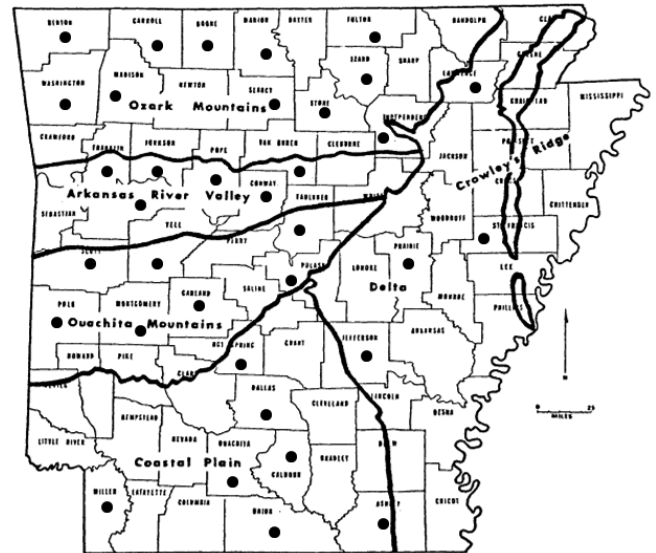


Figure 1. County outline map of Arkansas showing major physiographic regions with dots (●) in 35 counties having USNTC records of ticks; some counties have multiple records.

likely from a bat). Additional *O. kelleyi* were reported from cave-dwelling big brown bats, *Eptesicus fuscus*. This tick has been recorded from several species of bats across North America (Cooley and Kohls 1944a). *USNTC records* (Fig. 2): 1F, in building, Stone Co., Mountain View, 1952, JLL (RML 31120). 1M ex *Columbia livia*, Stone Co., Apr. 1954, JLL (RML 32974). 9L ex *E. fuscus*, Benton Co., War Eagle (bat cave), 3 Mar. 1962, JLL (RML 37888).

***Ornithodoros concancensis* Cooley and Kohls – no common name.** Lancaster (1973) reported this tick from a nest of an eastern phoebe (*Sayornis phoebe*) in Stone County (Fig. 2). However, it is typically an ectoparasite of bats and has also been collected from bat roosts (Cooley and Kohls 1944a).

***Otobius megnini* Dugés – ear tick.** Immature stages of this tick typically parasitize ungulates (but it can also feed on humans) and are often found in the internal ear canal where the spinose nymphal integument facilitates attachment. Adults do not feed. This tick is native to Mexico and the southwestern United States (Cooley and Kohls 1944a). However, livestock, especially cattle, moved from these regions can introduce *O. megnini* into new areas. This occurred in the early 1950s in Arkansas when herds of cattle were imported from Texas. Lancaster (1973) reported 3 established foci of this tick in Arkansas (Independence, Izard, and Yell counties) and reported other specimens from Franklin and Logan counties (Fig. 3). Lancaster

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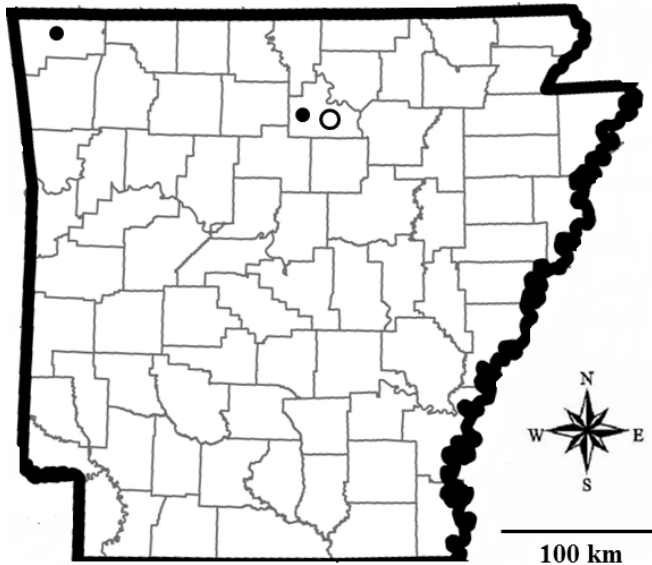


Figure 2. USNTC records of *Carios (Ornithodoros) kelleyi* (solid dots) and *Ornithodoros concancensis* (open dot) in AR.

(1984) advocated using acaricide-impregnated ear tags for controlling this tick on Arkansas livestock. There do not appear to be any currently established foci of this tick in Arkansas but humans visiting endemic areas or livestock being imported could be infested.

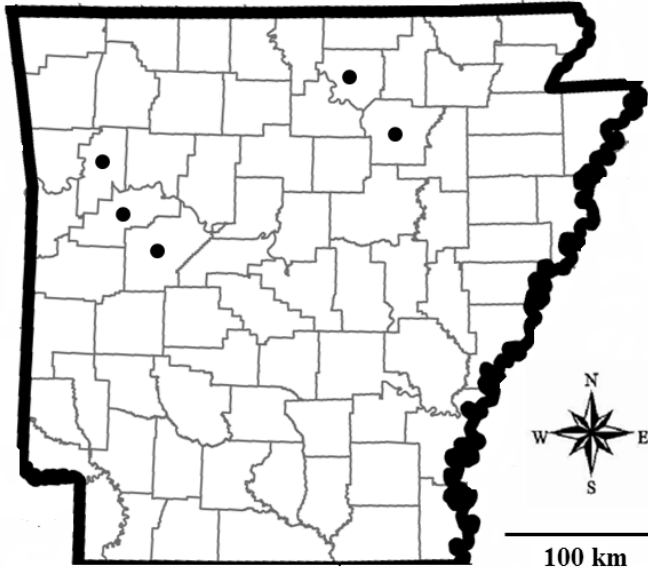


Figure 3. Records of *Otobius megnini* (solid dots) in AR.

Family Ixodidae (hard ticks)

***Amblyomma americanum* (Linnaeus) – Lone Star tick.** This is one of the most abundant tick species in the eastern United States (Cooley and Kohls 1944b). In Arkansas it almost certainly occurs in every county

although USNTC voucher specimens are available for only 21 counties (Fig. 4). Adults parasitize a variety of medium to large-sized mammals, especially white-tailed deer (*Odocoileus virginianus*), whereas immatures feed on various birds and mammals (Cooley and Kohls 1944b, Richardson et al. 1994, Polechla was 1996). The host list for the Lone Star tick in Arkansas summarized by Lancaster (1973) and included several mammals as well as birds. Koch (1982) reported *A. americanum* to be the second most abundant tick parasitizing domestic dogs in northwestern Arkansas. Lancaster (1955, 1957a, b), Lancaster et al. (1982a, b) and Meyer et al. (1982) provided data on the biology, seasonality and control of *A. americanum* in Arkansas. Hair and Howell (1970) studied the biology and control of this tick in Ozark recreation areas. Trout et al. (2010a) provided data on the population genetics of *A. americanum* in Arkansas. Trout and Steelman (2010) documented a wide distribution for *A. americanum* in Arkansas with most specimens being collected from canines and deer from May through August.

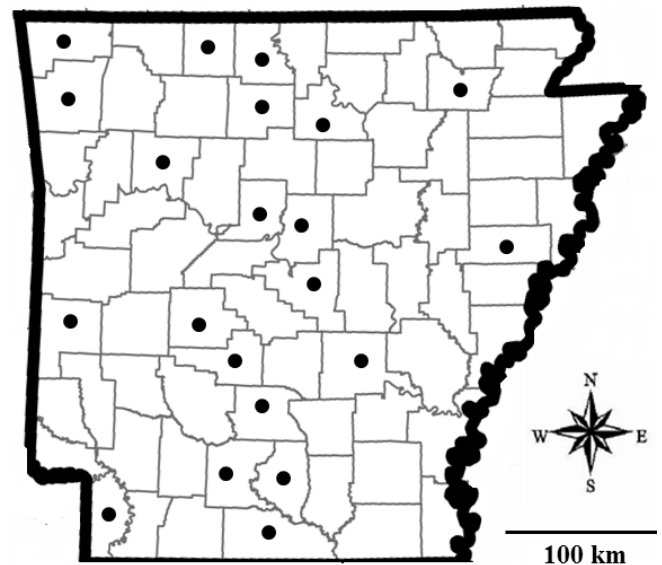


Figure 4. USNTC records of *Amblyomma americanum* (solid dots) in AR.

Washburn and Tuohy (1949) discussed the high prevalence of tularemia in humans and wildlife in Arkansas and Calhoun (1954) highlighted the role of *A. americanum* as a vector of *F. tularensis* in Arkansas. Eisen (2007) recommended additional investigations into tick-borne transmission of *F. tularensis* in Arkansas and Missouri. *Amblyomma americanum* is also a vector for several other agents, including those that cause HME, a form of granulocytic ehrlichiosis

caused by *Ehrlichia ewingii*, Southern Tick Associated Rash Illness (STARI) (possible agent, *Borrelia lonestari*), American boutonneuse fever caused by *Rickettsia parkeri* and feline cytauxzoonosis caused by *Cytauxzoon felis* (Childs and Paddock 2003, Goddard 2003, Trout and Steelman 2010, Killmaster et al. 2015). Further, *A. americanum* has been implicated as a zoonotic vector of 2 recently documented human pathogens, Heartland virus in Missouri (Savage et al. 2013) and Bourbon virus in Kansas (Kosoy et al. 2015). Cross reactivity between salivary proteins from *A. americanum* and galactose- α -1,3-galactose (“alpha-gal”) in consumed food can also lead to red meat allergies in humans (Commins et al. 2011). Although this tick has not historically been considered to be a vector of *R. rickettsii*, Breitschwerdt et al. (2011) documented transmission of this agent by *A. americanum* in North Carolina. Goddard and McHugh (1990) documented severe parasitism by *A. americanum* of military personnel at Little Rock Air Force Base during field training exercises. Schwartz et al. (1996) reported anti-tick salivary gland protein antibody seroconversion in military personnel exposed to *A. americanum* bites at Fort Chaffee. More recently, McAllister et al. (2013a) reported 5 and 24 nymphs of *A. americanum* on 2 eastern fox squirrels (*Sciurus niger*) from Marion County.

USNTC records: Ex *Canis familiaris* (104A) & *B. taurus* (134A, 1N), Boone Co., Harrison, 6–7 Jun. 1938, C.B. Philip & D. Conroy (RML 14191–14192, 14196). 1M, 1F ex *Equus caballus*, Boone Co., Harrison, C.B. Philip & D. Conroy, 6 Jun. 1938 (RML 14193). 12A ex *E. caballus* & *Bos taurus*, Boone Co., near Alpena, 6 Jun. 1938, C.B. Philip & D. Conroy (RML 14813). 1F ex *Homo sapiens*, Benton Co., Fayetteville, May 1938, H.H. Schwardt (RML 14816). 2M, 2F, 1N ex *C. familiaris*, Boone Co., Lead Hill, 14 Mar. 1939, SJC (RML 15506). 16M, 12F ex *C. familiaris* & *B. taurus*, Dallas Co., Sparkman, 3 Apr. 1939, SJC (RML 15516–15517). 8F ex *B. taurus*, Calhoun Co., Locust Bayou, 4 Apr. 1939, SJC (RML 15520). 1F, 18N, 60L, host not stated, Boone Co., near Bergeman, 2 Aug. 1939, SJC (RML 16005). 4A, 12N ex *C. familiaris*, Boone Co., Harrison, 1 Aug. 1939, S.J. Carpenter (RML 16006). 14M, 75F ex *C. familiaris*, *E. caballus* & *B. taurus*, Marion Co., near Lead Hill, 5 Jul. 1939, SJC (RML 16653). 26M, 82F ex *C. familiaris*, Boone Co., Bergeman, 7 Jul. 1939, SJC (RML 16654). 18M, 42F ex *C. familiaris*, Boone Co., near Denver, 6 Jul. 1939, SJC (RML 16655–16656). 38N, 22L, host & date not stated, Garland Co., H. H. Little (RML 19047–19048). 1N, 5L ex *C.*

familiaris, date not stated, Garland Co., H.H. Little (RML 19049). 2N ex *H. sapiens*, locality not stated, 3 Sept. 1941, W.J. Gertsch (RML 19586). 3N ex *H. sapiens*, Hot Springs, Garland Co., 20 Jun. 1943, WJB (RML 19690). 1M, host not stated, Washington Co., near Fayetteville, 20 Jun. 1943, WJB (RML 20274). 1F ex *H. sapiens*, Washington Co., near Fayetteville, 10 Jul. 1943, WJB (RML 20291). 1F, host not stated, Union Co., near Marysville, Jul. 1943, WJB (RML 20292). 2F, 1N, host not stated, Ouachita Co., near Camp Albert Pike, Jul. 1943, WJB (RML 20293). 1N ex *H. sapiens*, Lawrence Co., Blackrock, 7 Sept. 1942, C.R. Joyce (RML 22080). 2N ex *Sciurus niger*, Boone Co., 1 mi S. Valley Springs, 20 Apr. 1947, H.B. Hungerford (RML 23729). 23M ex *C. familiaris*, Boone Co., 1 mi S. Valley Springs, 18 Apr. 1947, H.B. Hungerford (RML 23743). 1M, 1F, host not stated, Benton Co., Rogers, Devil’s Den, 6 Jun. 1946, M.W. Sanderson (RML 23755–23756). 233A ex *E. caballus*, *B. taurus* & drag cloths, Polk Co., 4 mi SW Mena, 3–4 July 1947, J. M. Brennan (RML 23884–23889) 12A, 10N ex *B. taurus*, *C. familiaris* & vegetation, Polk Co., 1 mi SW Hatfield, 6 Jul. 1947, J.M. Brennan (RML 23890–23892). 30A, 3N ex *C. familiaris*, Polk Co., 3.5 mi NW Hatfield, 7 Jul. 1947, J.M. Brennan (RML 23893). 25A, 50N, drag cloth, Polk Co., 3.5 mi NW Hatfield, 7 Jul. 1947, J.M. Brennan (RML 23894). ex *S. niger* (1N), *C. familiaris* (2A, 4N, ~40L), *Sylvilagus floridanus* (“several” L) & drag cloths (28A, ~250N), Polk Co., 5 mi NW Hatfield, 7–8 Jul. 1947 (RML 23896–23901). 51A ex *B. taurus*, Polk Co., 10 mi W. Mena, 11 Jul. 1947, J. M. Brennan (RML 23904). 2L ex *H. sapiens*, Washington Co., Fayetteville, 1945, WJB (RML 24021). 1M ex *Felis catus*, Washington Co., 29 Apr. 1950, WJB (RML 27777). 2M ex *Felis catus*, Benton Co., 6 May 1950, WJB (RML 27778). 3F, 2N ex *F. catus*, Searcy Co., 21 Mar. 1950, WJB (RML 27779). 1F ex *F. catus*, Faulkner Co., 21 Mar. 1950, WJB (RML 27780). 1N ex *H. sapiens*, Hot Spring Co., 8 Apr. 1950, WJB (RML 27781). 1M, 2F ex *H. sapiens*, Conway Co., 14 Mar. 1950, WJB (RML 27782). 1N ex *H. sapiens*, Washington Co., 14 Mar. 1950, WJB (RML 27783). 11M, 3F, 1N ex *E. caballus*, Washington Co., May 1950, WJB (RML 27784–27785). 1F ex *E. caballus*, Miller Co., 9 Apr. 1950, WJB (RML 27786). 1M, 7F ex “rabbit,” Washington Co., 5 May 1950, W.J. Baerg (RML 27788). 1N ex “rabbit,” Searcy Co., 21 May 1950, WJB (RML 27789). Ex *Ovis aries* (2M, 3F), *B. taurus* (1N) and *C. familiaris* (1N), Washington Co., Apr. & May 1950, WJB (RML 27790, 27792–27793). 1N ex *C. familiaris*, Hot Spring Co., 8 Apr. 1950, WJB (RML

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27795). 4N, ex *C. familiaris*, Pulaski Co., 11 May 1950, WJB (RML 27796). 2F ex *C. familiaris*, Ouachita Natl. Forest, 13 May 1950, WJB (RML 27797). 1F ex *C. familiaris*, Washington Co., 21 May 1950, WJB (RML 27799). 1F ex *C. familiaris*, St. Francis Co., 6 mi N. Forrest City, 1 Aug. 1951, E.L. Calhoun (RML 30760). 26 N, ex *S. floridanus*, Stone Co., Marcella, 24 Mar. 1948, F.C. Wonder (RML 31808). 2N, ex *N. floridana*, Stone Co., Marcella, 25 Mar. 1948, FCW (RML 31811). 1M, host not stated, Lawrence Co., Jul. 1922, B.C. Marshall (RML 31813). 10L ex *C. familiaris*, Jefferson Co., Pine Bluff, 26 Jul. 1940, J. D. Morton (RML 57348). 14 N ex *O. virginianus* Miller Co., Texarkana, 6 Aug. 1911, "G.N.W." (RML 57735). 1M, 3F ex *H. sapiens*, "Pettigrew and Rich mountains," Jun. 1910, A.H. Howell (RML 57748). 1M, host not stated, Dallas Co., 10 Jun. 1973, M. J. Rowland (RML 105740). 2M, 1F, 3N ex *Lontra canadensis*, localities and dates not stated, P.J. Polechla (RML 117912–117914). 1F, vegetation, Pulaski Co., Little Rock Air Force Base, 23 Jul. 1987, J. Goddard (RML 118550). 1M ex *H. sapiens*, Johnson Co., Ozark Natl. Forest, 5 Jun. 1990, W.T. Denny (RML 119978).

***Amblyomma maculatum* (Koch) – Gulf Coast tick.** Historically, this tick has not been common in Arkansas but its range has been expanding northwards from the Gulf Coast region in recent years (Teel et al. 2010, Paddock and Goddard 2015). It is now established in Arkansas (Trout and Steelman 2010, Trout et al. 2010b). Adults feed on a variety of large mammals such as deer and cattle whereas immatures feed on smaller mammals and on birds (Cooley and Kohls 1944b, Teel et al. 2010). Lancaster (1973) recorded *A. maculatum* from Ashley County on cattle and from Washington County via dragging techniques. Koch (1982) documented *A. maculatum* from domestic dogs in northwestern Arkansas. This tick is a vector for the causative agent of American boutonneuse fever, *R. parkeri* and its attachment can also cause a disfiguring condition called gotch ear in livestock animals that can lead to secondary bacterial infections (Teel et al. 2010, Paddock and Goddard 2015). Trout et al. (2010c) detected *R. parkeri* and *Candidatus* Rickettsia amblyommii in *A. maculatum* from Arkansas.

USNTC records (Fig. 5): 1M ex *C. familiaris*, Hot Spring Co., 4 mi E. Point Cedar, 26 Jul. 1950, C.E. Hopla (RML 27731). 1M ex *H. sapiens*, Pope Co., near Russellville, 22 Jul. 1993, C.D. Steelman (RML 121362).

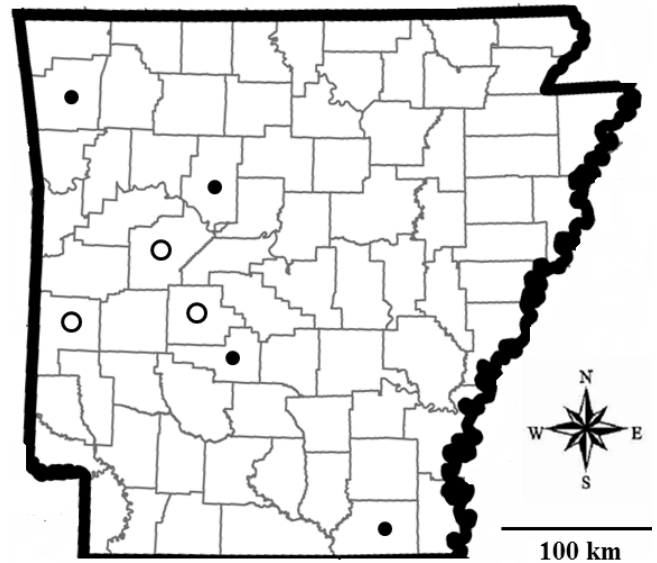


Figure 5. USNTC records of *Amblyomma maculatum* (solid dots) and *Dermacenter albipictus* (open dots) in AR.

***Dermacenter albipictus* (Packard) – winter tick.** This one-host tick parasitizes a variety of ungulates including cattle, horses and white-tailed deer and is widely distributed throughout North America (Strickland et al. 1976) but there are relatively few records from Arkansas. Lancaster et al. (1982a) used low daily oral doses of Ivermectin to control *D. albipictus* on calves in Arkansas.

USNTC records (Fig. 5): "Many" A ex *O. virginianus*, "eastern Arkansas," Nov. 1937, H.H. Schwardt (RML 14818). 1F ex *O. virginianus*, Yell Co., 7 mi S. Bluffton, 18 Nov. 1950, JLL (RML 29195). 1F ex *E. caballus*, Polk Co., 2 Dec. 1950, Q.S. Dagenhart (RML 29196). 2M, 6F ex *O. virginianus*, Garland Co., Ouachita National Forest, 12–14 Nov. 1979, DAS (RML 109653, 109655). 3M, 4F ex *O. virginianus*, Yell Co., Ouachita National Forest, Nov. 1979, DAS (RML 109657, 109695–109696). 3F ex *O. virginianus*, Yell Co., 14–15 Nov. 1979, DAS (RML 109658, 109659).

***Dermacenter variabilis* (Say) – American dog tick.** This tick is widely distributed in the eastern United States and in some western states (Strickland et al. 1976). It probably occurs statewide in Arkansas but there are USNTC vouchers from only 19 counties (Fig. 6). Trout and Steelman (2010) documented *D. variabilis* from canines, felines and deer from several Arkansas counties mainly from March through August. Adults typically parasitize carnivores (especially domestic dogs), humans and other large mammals (Koch 1982). Immatures mainly parasitize rodents including cotton rats (*Sigmodon hispidis*), white-footed

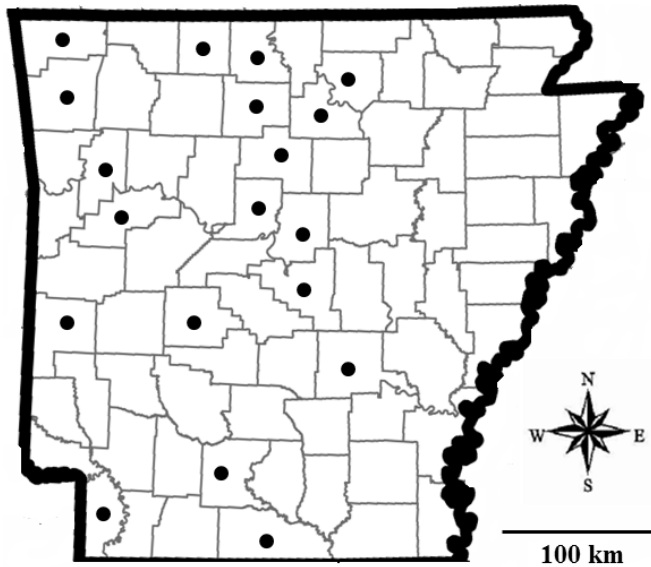


Figure 6. USNTC records of *Dermacenter variabilis* (solid dots) in AR.

mice (*Peromyscus leucopus*) and deer mice (*Peromyscus maniculatus*) (Strickland et al. 1976). Immature stages also parasitize rabbits and birds. McAllister et al. (2013a) reported 1 larval and 2 male *D. variabilis* on *S. niger* from Marion County, and a single southern flying squirrel (*Glaucomys volans*) from Union County harbored a larval American dog tick. Tumilson et al. (2015) reported *D. variabilis* from golden mice, *Ochrotomys nuttalli* from Union County, and white-footed mice, (*P. leucopus*), and a hispid cotton rat (*S. hispidus*) from Marion County.

This tick is the primary vector for the causative agents of RMSF and tularemia. Warner et al. (1996) documented 11 human cases of tick-associated RMSF in military personnel following field training exercises at Little Rock Air Force Base. Lancaster et al. (1982a) used oral doses of Ivermectin to control *D. variabilis* on calves in Arkansas.

USNTC records: Ex *C. familiaris* (13M, 5F) & *B. taurus* (1M), Boone Co., Harrison, 6–7 Jun. 1938, C.B. Philip & D. Conroy (RML 14191, 14192, 14196). 2A, host not stated, Boone Co., near Bergeman, 2 Aug. 1939, SJC (RML 16005). 21F ex *C. familiaris*, Boone Co., Harrison, 1 Aug. 1939, SJC (RML 16006). 2F ex *C. familiaris*, Marion Co., near Lead Hill, 5 Jul. 1939, SJC (RML 16653). 11A ex *C. familiaris*, Boone Co., Bergeman, 7 Jul. 1939, SJC (RML 16654). 22A ex *C. familiaris*, Boone Co., near Denver, 6 Jul. 1939, SJC (RML 16655, 16656). 1M, 1F, host & date not stated, Garland Co., H.H. Little (RML 19047, 19048). 1F ex *C. familiaris*, date not stated, Garland Co., H.H. Little (RML 19049). 1M, host not stated, Washington Co.,

near Fayetteville, 20 Jun. 1943, WJB (RML 20274). 1F ex *H. sapiens*, Washington Co., near Fayetteville, 10 Jul. 1943, WJB (RML 20291). 1F, host not stated, Union Co., near Marysville, Jul. 1943, WJB (RML 20292). 2M, 3F, host not stated, Ouachita Co., near Camp Albert Pike, Jul. 1943, WJB (RML 20293). 1M, host and date not stated, Logan Co., Mount Magazine, WJB (RML 21727). 8L ex *S. hispidus*, Boone Co., 1 mi S. Valley Springs, 20 Apr. 1947, H.B. Hungerford (RML 23734). 1F, drag cloth, Polk Co., 4 mi SW Mena, 3–4 Jul. 1947, J.M. Brennan (RML 23886). 1A ex *C. familiaris*, Polk Co., 1 mi SW Hatfield, 6 Jul. 1947, J.M. Brennan (RML 23892). 9A ex *C. familiaris* & unidentified host, Polk Co., 3.5 mi NW Hatfield, 7 Jul. 1947, J. M. Brennan (RML 23893, 23895). 1M, drag cloth, Polk Co., 5 mi NW Hatfield, 8 Jul. 1947, J.M. Brennan (RML 23899). 1M ex *F. catus*, Washington Co., 29 Apr. 1950, WJB (RML 27777). 1F ex *H. sapiens*, Conway Co., 14 Mar. 1950, WJB (RML 27782). 9M, 4F ex *E. caballus*, Washington Co., May 1950, WJB (RML 27784– 27785). 1F ex “rabbit,” Searcy Co., 21 May 1950, WJB (RML 27789). 1M ex *C. familiaris*, Miller Co., 8 Apr. 1950, WJB (RML 27791). 1M, 1F ex *B. taurus*, Washington Co., 29 Apr. 1950, WJB (RML 27792). 1M ex *C. familiaris*, Izard Co., 8 Apr. 1950, WJB (RML 27794). 4M ex *C. familiaris*, Ouachita Co., 13 May 1950, WJB (RML 27797) 1F ex *C. familiaris*, Benton Co., 6 Jun. 1950, WJB (RML 27798). 5M, 6F ex *C. familiaris*, Washington Co., 21 May 1950, WJB (RML 27799). 2L ex *P. maniculatus*, Stone Co., Marcella, 22 Mar. 1948, FCW (RML 31804). 5N, 1L ex *Peromyscus* sp., Franklin Co., Fly Gap Tower, 15 Jun. 1948, C.C. Sanborn (RML 31806). 1N, 1L ex *Neotoma floridana*, Stone Co., Marcella, 24 Mar. 1948, FCW (RML 31807). 2L ex *Reithrodontomys fulvescens*, Stone Co., Marcella, 23 Mar. 1948, C.C. Sanborn (RML 31809). 5N, 5L ex *S. floridanus*, Jefferson Co., Pine Bluff, 16 Mar. 1954, C.M. Clifford (RML 37564). 18A ex *C. familiaris*, Washington Co., Fayetteville, Jun. 1963, JLL (RML 38915). 38A, host and location not stated, 8 Jun. 1966, JLL (RML 46874). 1F ex *H. sapiens*, Faulkner Co., Conway, 18 Jun. 1910, A.H. Howell (RML 59461). 6M, 7F, drag cloth, Pulaski Co., Little Rock Air Force Base, 23 Jul. 1987, J. Goddard (RML 118549). 1M, drag cloth, Pulaski Co., Camp Robinson, 23 Jul. 1987, J. Goddard (RML 118551). 2M, 1F ex *Procyon lotor*, Van Buren Co., Sept. 1989, D.J. Richardson (RML 120864).

***Haemaphysalis leporispalustris* (Packard) – rabbit tick.** This tick is widely distributed across North

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America (Cooley 1946). Adults mainly parasitize rabbits (*Sylvilagus* spp.) whereas immatures parasitize rabbits and a wide variety of ground-frequenting bird species (Cooley 1946, Lancaster 1973). It is an enzootic vector for the causative agents of tularemia and RMSF (Strickland et al. 1976).

USNTC records (Fig. 7): 41M, 2F, 9N ex *Sylvilagus* sp., Washington Co., Fayetteville, 5-6 Jun. 1938, C.B. Philip & D. Conroy (RML 14393, 14394, 14395, 14396). A (no. not stated) ex *Sylvilagus* sp., Boone Co., Harrison, 6-7 Jun. 1938, C.B. Philip & D. Conroy (RML 14398, 14399, 14814). 2N, host not stated, Washington Co., 11 Oct. & 3 Nov. 1941, H. Ross & C.O. Mohr (RML 21018, 23063). "several" A, N & L ex *S. floridanus*, Polk Co., 5 mi NW Hatfield, 8 July 1947, J.M. Brennan (RML 23897). 1F ex *F. catus*, Searcy Co., 21 Mar. 1950, WJB (RML 27779). 5F ex rabbit, Searcy Co., 21 May 1950, WJB (RML 27789). "numerous A, N & L" ex *S. floridanus*, Independence Co., 8 mi N. Batesville, 1 Apr. 1948, FCW (RML 31803). 6A ex swamp rabbit, *Sylvilagus aquaticus*, Independence Co., 8 mi N. Batesville, 1948, FCW (RML 31805). ~25A, N, & L ex *S. floridanus*, Stone Co., Marcella, 24 Mar. 1948, FCW (RML 31808, 31810). 1M ex *N. floridana*, Stone Co., Marcella, 25 Mar. 1948, FCW (RML 31811). ~30A, N & L ex *S. aquaticus*, Independence Co., 8 mi N. Batesville, 25 Mar. 1948, FCW (RML 31814). 4M, 4F, 2N, 2L ex *S. floridanus*, Independence Co., Batesville, 1 Apr. 1948, FCW (RML 89879).

Ixodes baergi Cooley and Kohls – no common name.

This tick was described from Washington County, Arkansas specimens by Cooley and Kohls (1942). It is a host-specific ectoparasite of cliff swallows (*Petrochelidon pyrrhonota*) and has been recorded from a few additional U.S. states as well as Arkansas (Baerg 1944, Larimore 1987, Keirans and Clifford 1978, Keirans et al. 1993, Durden and Keirans 1996b).

USNTC records (Fig. 7): 5M, 5F ex *P. pyrrhonota*, Washington Co., 21 Jun. 1941, WJB (RML 19248) (Type series). 52A ex *P. pyrrhonota*, Benton Co., Rogers, 1942, W.R. Horsfall (RML 23754). ~55A & N ex *P. pyrrhonota*, Benton Co., 8 & 20 Jun. 1944, JLL (RML 30466, 30603). 6M, 47F, 3L ex *P. pyrrhonota*, Benton Co., 19 Jul. 1942, 6 Jul. 1943 & 19 Apr. 1944, R.W. Larimore (RML 120942–120945) (returned to Illinois Natural History Survey Collection).

Ixodes banksi Bishopp – no common name. This tick was described from specimens (15 females, 7 males) collected from a muskrat (*Ondatra zibethicus*)

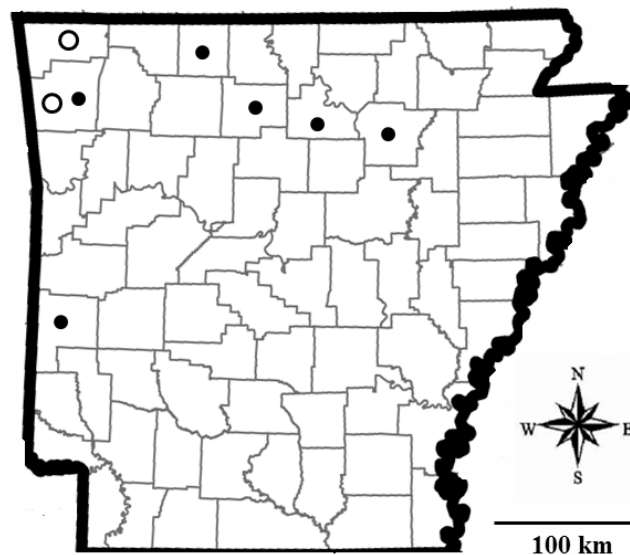


Figure 7. USNTC records of *Haemaphysalis leporispalustris* (solid dots) and *Ixodes baergi* (open dots) in AR.

from Mammoth Spring, Fulton County, Arkansas (Bishopp 1911). However, it is typically a parasite of the American beaver (*Castor canadensis*) (Keirans and Clifford 1978, Durden and Keirans 1996b). No other records of this tick have been reported from Arkansas since the original description over a century ago.

USNTC records: (Fig. 8) Ex *O. zibethicus*, Fulton Co., Mammoth Spring, date not listed, N. Banks (RML 18727). 1F, 1N ex *O. zibethicus*, Fulton Co., Mammoth Spring, 4 Jun. 1910, coll. not stated (RML 49303) (Paratypes). 3E ex *O. zibethicus*, Fulton Co., Mammoth Spring, date not listed, N. Banks (RML 18727). 4F ex *O. zibethicus*, Fulton Co., Mammoth Spring, 14 Jun. 1910, A.H. Howell (RML 56789) (Type Series).

Ixodes brunneus Koch – no common name. This is strictly a bird-feeding tick reported from a variety of avian hosts. In Arkansas, single specimens were reported previously from an eastern hermit thrush (*Catharus guttatus*) from northwestern Arkansas and slate-colored junco (*Junco hyemalis*) from North Little Rock by Lancaster (1973).

USNTC records: (Fig. 8) 1F ex *Junco* sp., Pulaski Co., North Little Rock, 12 Jan. 1943, R. Thomas (RML 19670). 1F ex *Zonotrichia albicollis*, North Little Rock, 10 Apr. 1943, R. Thomas (RML 20192). 3F ex *Cyanocitta cristata*, Pulaski Co., North Little Rock, 24 Feb. 1941, R. Thomas (RML 20196). 2F ex *J. hyemalis* & *Zonotrichia quercula*, Pulaski Co., North Little Rock, 1 Feb. 1944, R. Thomas (RML 20541–20542). 1F ex *Mimus polyglottus*, Pulaski Co., North Little

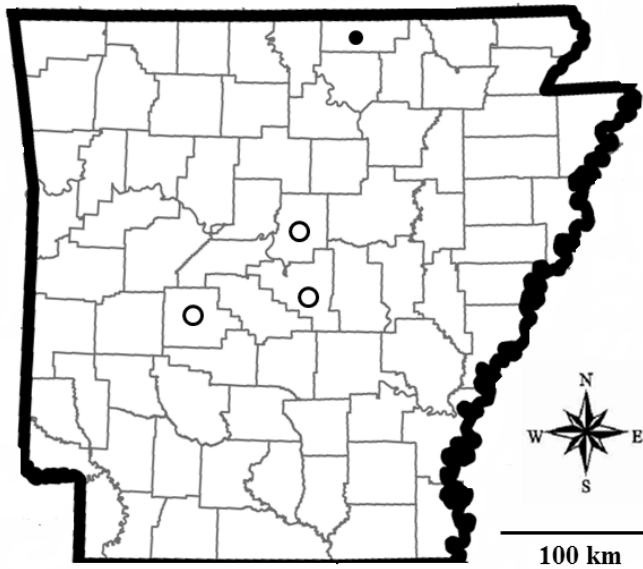


Figure 8. USNTC records of *Ixodes banksi* (solid dots) and *Ixodes brunneus* (open dots) in AR.

Rock, 18 Feb. 1944, R. Thomas (RML 20856). 2F ex *J. hyemalis*, Pulaski Co., North Little Rock, Feb. & Apr. 1944, R. Thomas (RML 20857, 20938). 5F ex *Z. albicollis*, Pulaski Co., North Little Rock, Apr. 1944, R. Thomas (RML 20935–20937, 21367). 1F ex *Bombycilla cedrorum*, Garland Co., Hot Springs, 27 Feb. 1958, S. O. Hill (RML 34615). 9F, 2N ex *Carpodacus purpureus* & *Cardinalis cardinalis*, Conway Co., Morrilton, 3 Feb. 1967, R. Thomas, (RML 47487). 2F ex *Junco* sp., Pulaski Co., Little Rock, Jan. 1941, R. Thomas (RML 66134).

***Ixodes cookei* Packard – no common name.** This tick infests a variety of medium-sized mammals, especially carnivores, including dogs, raccoons, skunks, and weasels (Keirans and Clifford 1978, Durden and Keirans 1996b). In Arkansas, it has previously been reported from the Virginia opossum (*Didelphis virginiana*), mink (*Mustela vison*), striped skunk (*Mephitis mephitis*), gray fox (*Urocyon cinereargenteus*), raccoon (*Procyon lotor*), river otter (*L. canadensis*) and eastern woodrat (*N. floridana*) (Lancaster 1973, Richardson et al. 1994, Polechla 1996). Koch (1982) also reported *I. cookei* from domestic dogs in Arkansas. Powassan virus and *B. burgdorferi* have been detected in *I. cookei* (Durden and Keirans 1996b) but this tick is not considered to be a vector of the latter agent.

USNTC records: (Fig. 9) 1F ex *C. familiaris*, Boone Co., Harrison, 6 Jun. 1938, C.B. Philip & D. Conroy (RML 14191). 1F ex *C. familiaris*, Boone Co., Harrison, 1 Aug. 1939, SJC (RML 16006). 1F ex *C.*

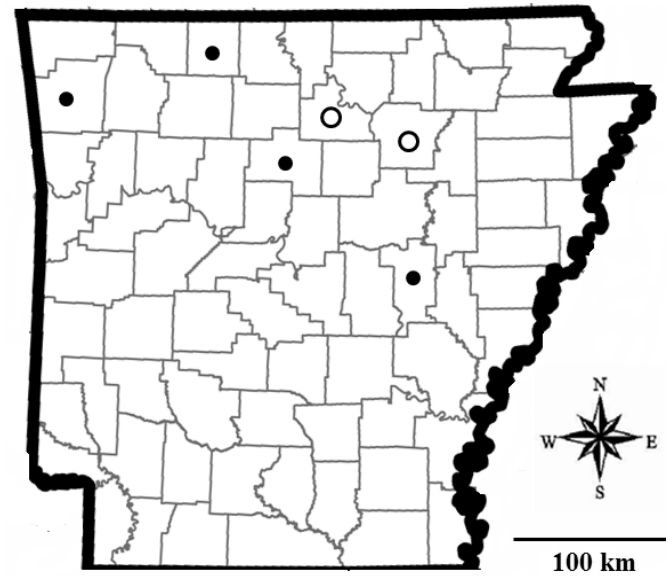


Figure 9. USNTC records of *Ixodes cookei* (solid dots) and *Ixodes dentatus* (open dots) in AR.

familiaris, Boone Co., near Denver, 6 Jul. 1939, SJC (RML 16655). 1F, host & coll. not stated, Washington Co., Corkscrew Cave, 12 Nov. 1938 (RML 18526). 4F ex *M. vison*, Prairie Co., Hazen, 10 Jan. 1948, C.L. Gates (RML 24728). 1N ex skunk, locality not stated, Fall 1949, WJB (RML 27372). 2F ex *L. canadensis*, locality not stated, 1985, P.J. Polechla (RML 117911). 7F, 19N, 13L ex *P. lotor*, Van Buren Co., 4 Nov. 1989 & 20 Jan. 1990, D. J. Richardson (RML 120865–120866).

***Ixodes dentatus* Marx – no common name.** This tick is an important ectoparasite of rabbits (Keirans and Clifford 1978). However, immature stages also parasitize a variety of bird species (Durden and Keirans 1996b). The spirochete *Borrelia andersoni*, which is closely related to the agent of Lyme disease, has been detected in this tick (Durden and Keirans 1996b). Lancaster (1973) reported this tick from several rodents and also from swamp rabbit (*S. aquaticus*), Carolina wren (*Thryothorus ludovicianus*) and brown thrasher (*Toxostoma rufum*) in Arkansas.

USNTC records (Fig. 9): 11M, 6F, 8N ex *S. floridanus*, Independence Co., 8 mi N. Batesville, 1 Apr. 1948, F.C. Wonder (RML 31803, 92264). 1M, 1N, 2L ex *S. floridanus*, Stone Co., Marcella, 24 Mar. 1948, F.C. Wonder (RML 31810).

***Ixodes marxi* Banks – no common name.** This tick typically parasitizes squirrels (Durden and Keirans 1996b). In Arkansas, it was documented previously from gray squirrels (*S. carolinensis*) by Lancaster

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(1973). In addition, McAllister et al. (2013a) reported a single female *I. marxi* on *S. niger* from Marion County.

USNTC records (Fig. 10): 4F ex *S. carolinensis*, Washington Co., near Fayetteville, 4 Dec. 1949, WJB (RML 27092). 1F ex squirrel, locality not stated, Fall 1949, WJB (RML 27373). 5F ex *S. niger*, Madison Co., locality not stated, 12 Oct. 1946, JLL (RML 33129).

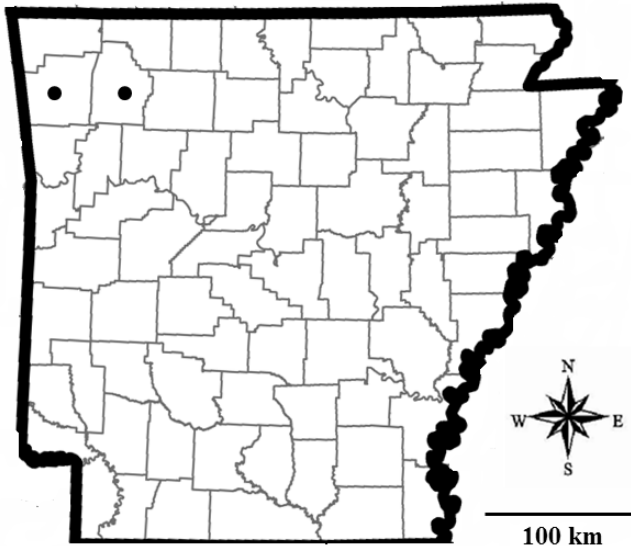


Figure 10. USNTC records of *Ixodes marxi* (solid dots) in AR.

***Ixodes scapularis* Say – blacklegged tick.** This is a common and widespread tick in Arkansas (Trout et al. 2009, Trout and Steelman 2010, Eisen et al. 2016) although USNTC vouchers are known from only 19 counties (Fig. 11). Eisen et al. (2016) reported *I. scapularis* to be established in 27 Arkansas counties and reported it from a further 25 Arkansas counties. Adults parasitize medium to large-sized mammals including ungulates, carnivores, lagomorphs and humans (Keirans and Clifford 1978, Koch 1982, Richardson et al. 1994, Keirans et al. 1996, Eisen et al. 2016) whereas immatures parasitize the same hosts plus a wide range of small mammals, birds and reptiles (Durden and Keirans 1996b, Keirans et al. 1996, Whalley 1999). Immature stages (both nymphs and larvae) are common on lizards in Arkansas including green anole (*Anolis carolinensis*), five-lined skink (*Plestiodon fasciatus*), broad-head skink (*Plestiodon laticeps*), prairie lizard (*Sceloporus consobrinus*) and ground skink (*Scincella lateralis*) (McAllister et al. 2013b, 2014). This tick is the most important vector in eastern North America of the causative agents of Lyme disease, human granulocytic anaplasmosis (HGA) (caused by *Anaplasma phagocytophilum*) and

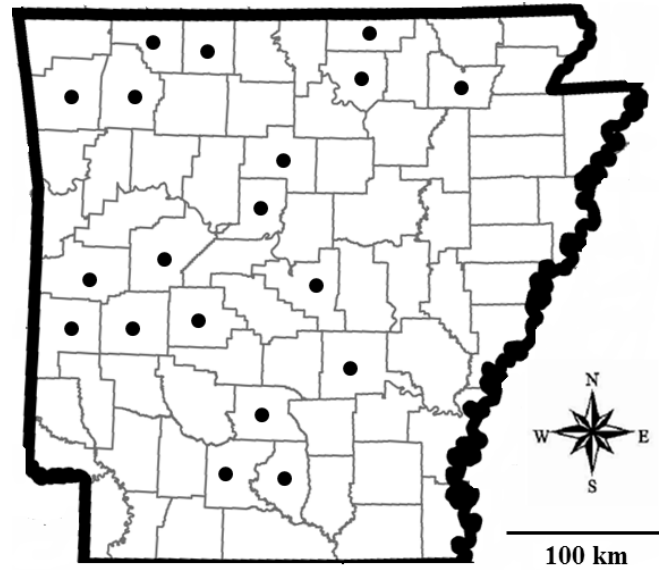


Figure 11. USNTC records of *Ixodes scapularis* (solid dots) in AR.

babesiosis (mainly caused by *Babesia microti*) (Durden and Keirans 1996b). It can also transmit other pathogens including deer tick virus, a variant of Powassan virus that causes Powassan encephalitis (Eisen et al. 2016). Simpson et al. (1993) and Gullo (1998) surveyed Arkansas ticks, mainly *I. scapularis*, for *B. burgdorferi*. Trout et al. (2009) studied the population genetics and phylogeography of *I. scapularis* parasitizing canines and deer in Arkansas. Trout-Fryxell et al. (2012) screened Arkansas ticks, canines and deer for borreliae.

USNTC records: 2F ex *Lynx rufus*, locality not stated, 1937, H.H. Schwardt (RML 14815). “Many” A ex *O. virginianus*, “eastern Arkansas,” Nov. 1937, H.H. Schwardt (RML 14818). 1F ex *C. familiaris*, Boone Co., Lead Hill, 14 Mar. 1939, SJC (RML 15506). 1M, 4F ex *C. familiaris* & *B. taurus*, Dallas Co., Sparkman, 3 Apr. 1939, SJC (RML 15516–15517). 1F ex *B. taurus*, Calhoun Co., Locust Bayou, 4 Apr. 1939, SJC (RML 15520). 1F ex *C. familiaris*, Conway Co., Morrilton, Mar. 1940, W. Dan (RML 17582). 1F ex *C. familiaris*, Pulaski Co., North Little Rock, 4 Feb. 1943, R. Thomas (RML 20193). 2M, 3F ex *C. familiaris* & 2M, 3F ex *O. virginianus* Madison Co., Huntsville, 20 Feb. 1944, WJB (RML 20760, 20854). 3F ex *C. familiaris*, Madison Co., Huntsville, Mar. 1944, WJB (RML 21023). 1M, 1F ex *B. taurus*, Garland Co., 20 Mar. 1946, R.L. Melton (RML 22342). 4F ex *B. taurus*, Boone Co., 1 mi S. Valley Springs, 19 Apr. 1947, H. B. Hungerford (RML 23739). 1N, drag cloth, Polk Co., 4 mi SW Mena, 3 Jul. 1947, J.M. Brennan (RML 23888). 2F ex *H. sapiens*, Polk Co., Hatfield, 29 Dec. 1947, J.P. Redman

(RML 246143). 1F ex *H. sapiens*, Carroll Co., Berryville, 12 Nov. 1949, WJB (RML 27181). Ex *C. familiaris* (2M, 8F) & *H. sapiens* (1M, 5F), early Fall 1949, locality not stated, WJB (RML 27367–27368). 1M ex *H. sapiens*, Washington Co., 23 Mar. 1949, WJB (RML 27369). 1F ex *B. taurus*, Izard Co., Fall 1949, WJB (RML 27370). 1F ex *F. catus*, Fulton Co., 23 Mar. 1949, WJB (RML 27371). 7M, 13F ex *H. sapiens*, *C. familiaris*, *E. caballus* & *B. taurus*, locality not stated, Fall 1949, WJB (RML 27374). 1F ex *C. familiaris*, Ouachita Co., 13 May 1950, WJB (RML 27797). 1M, 1F ex *U. cinereoargenteus*, Jefferson Co., Pine Bluff, 18 Nov. 1953, C.M. Clifford (RML 37562). 11F ex *C. familiaris*, Washington Co., Fayetteville, 10 Apr. 1964, JLL (RML 39575). 1M ex *B. taurus*, Montgomery Co., Mount Ida, 17 Nov. 1938, WJB (RML 58661). 1M, 1F (plus other specimen not listed?) ex *C. familiaris*, *E. caballus* & *B. taurus*, Lawrence Co., Mount Ida, 17 Nov. 1938, WJB (RML 66133). 2F ex *O. virginianus*, Scott Co., Waldron, 30 Oct. 1978, W. Montague (RML 105929). 10F ex *O. virginianus*, Ouachita National Forest, 16 & 30 Nov. 1978, W. Montague (RML 105970–105971). 2M, 8F ex *O. virginianus*, Garland Co., Ouachita National Forest, 12–14 Nov. 1979, DAS (RML 109653, 109654, 109655). 1M, 6F ex *O. virginianus*, Montgomery Co., Ouachita National Forest, 13 Nov. 1979, DAS (RML 109656). 7F ex *O. virginianus*, Yell Co., 14–15 Nov. 1979, DAS (RML 109658, 109659). 9M, 14F ex *O. virginianus*, Yell Co., Ouachita National Forest, Nov. 1979, DAS (RML 109657, 109695, 109696). 3M, 6F ex *O. virginianus*, Perry Co., Ouachita National Forest, Nov. 1978, DAS (RML 109694). 5M, 6F ex *O. virginianus*, Garland Co., Ouachita National Forest, Nov. 1978, DAS (RML 109697, 109698). 2N, 4L, hosts & localities not stated, 19 May 1977, M. Coan (RML 117509–117510). 2M, 1F ex *P. lotor*, Van Buren Co., 2 Mar. 1990, D.J. Richardson (RML 120867).

***Ixodes texanus* Banks – no common name.** This tick parasitizes a variety of carnivores across much of North America (Keirans and Clifford 1978, Durden and Keirans 1996b) but the only Arkansas records are from raccoons (Richardson et al. 1994).

USNTC records (Fig. 12): 7N, 1L & 1F, 1N ex *P. lotor*, Van Buren Co., 4 Nov. 1989, 20 Jan. 1990 & 9 Apr. 1990, D.J. Richardson (RML 120866, 120868).

***Ixodes woodi* Bishop – no common name.** This tick mainly parasitizes woodrats, *Neotoma* spp. in various parts of North America (Durden and Keirans 1996b).

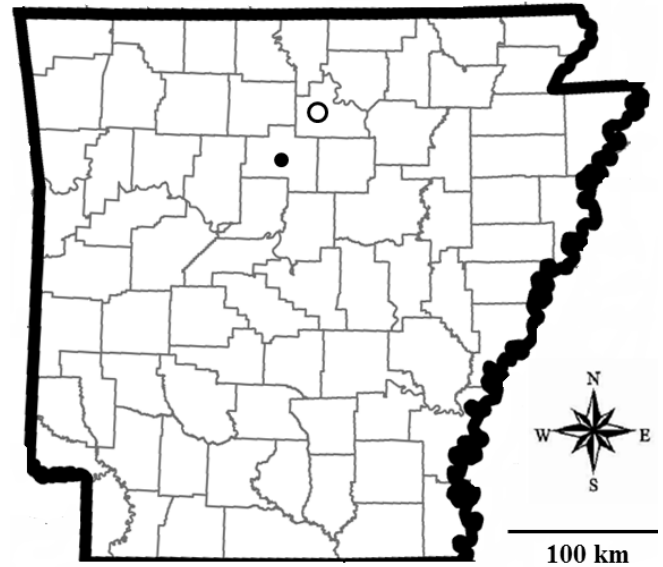


Figure 12. USNTC records of *Ixodes texanus* (solid dot) and *Ixodes woodi* (open dot) in AR.

Although the record is almost 70 yr old, we document this tick from Arkansas for the first time. Additional collections of *N. floridana* from the state should increase the number of county records for *I. woodi*.

USNTC record (Fig. 12): 1F, 4N, 5L ex *N. floridana*, Stone Co., Marcella, 24 Mar. 1948, FCW (RML 31812).

***Rhipicephalus (Boophilus) annulatus* (Say) – cattle tick.** This non-native, invasive one-host tick was formerly widespread in Arkansas (Cooley 1946, Lancaster 1973) but it had been all but eliminated from the USA by 1943 as a result of the Cattle Fever Tick Eradication Program initiated by USDA in 1906 (Strickland et al. 1976). Nevertheless, this tick can still be recorded along the Texas-Mexico border especially on parasitized livestock being brought into the states (Lohmeyer et al. 2011). All active stages feed on ungulates, including bison, cattle, deer, horses, goats, mules, and sheep. This economically important tick is a vector of *Babesia bigemina* and *Anaplasma marginale*, the causative agents of bovine babesiosis (also referred to as Texas cattle fever, redwater fever and bovine piroplasmiasis) and bovine anaplasmosis, respectively (Strickland et al. 1976).

***Rhipicephalus sanguineus* (Latreille) – brown dog tick.** This non-native invasive tick is the most widely distributed tick in the world (Leeson 1951, Walker et al. 2000). In North America, all active stages typically feed on domestic dogs (Walker et al. 2000). Koch

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(1982) reported *R. sanguineus* to be the most common tick parasitizing domestic dogs in northwestern Arkansas. Trout and Steelman (2010) also reported this tick to be a common ectoparasite of canines in the state. However, humans are also sometimes bitten. *Rhipicephalus sanguineus* can breed indoors often parasitizing dogs in large numbers and causing significant blood loss (Strickland et al. 1976). In the USA, this tick is the main vector of *Babesia canis*, a causative agent of canine babesiosis, and of *Ehrlichia canis*, a causative agent of canine ehrlichiosis (canine tropical pancytopenia) (Walker et al. 2000). Other pathogens or symbionts transmitted to dogs by *R. sanguineus* in North America include *R. rickettsii*, *Rickettsia rhipicephali* (a non-pathogenic SFGR), *Hepatozoon canis* (causative agent of canine hepatozoonosis), *Haemobartonella canis* (an epierythrocytic rickettsial parasite), *F. tularensis* and *Coxiella* sp. (Walker et al. 2000). This ectoparasite can also (rarely) cause tick paralysis in dogs (Walker et al. 2000). Recently, *R. sanguineus* has been shown to be a vector of *R. rickettsii* to humans in Arizona (Demma et al. 2005).

USNTC record: 1N ex *C. familiaris*, Pulaski Co., Little Rock, 17 Aug. 1945, WJB (RML 21973).

Discussion

We have provided a summation of the 19 ticks of Arkansas and note species that are vectors for disease agents. In addition, we report *I. woodi* in Arkansas for the first time. The county distribution of records for ticks in the state tends to show that the vast majority of records were obtained from various hosts in counties of the Interior Highlands (Ozarks and Ouachitas) (Fig. 1). Perhaps part of the reason for this distribution is the closer proximity of that region to the University of Arkansas, where most of the personnel who conducted previous tick research were employed. There are a moderate number of records in counties from the Gulf Coastal Plain; however, very few records are from far eastern Arkansas (Fig. 1). Additional collecting should be undertaken in those counties, particularly on Crowley's Ridge and in the Delta.

Acknowledgments

We thank Ms. Colleen R. Evans, Collections Manager at GSU, for making USNTC records and specimens of Arkansas ticks available for study. We dedicate this paper to the memory of Dr. J. L. "Jay" Lancaster, Jr. (1923-2016), Arkansas tick specialist

extraordinaire, who passed away during the production of this review.

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