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Historical Review and Field-based Study of Ticks on Domestic Goats in Oklahoma

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Abstract. Historical records of five genera and 11 species of ticks were reported on domestic goats in the United States in literature published before 1951. In a field-based collection from random goats and pastures in eastern Oklahoma, we collected three species and three life stages of ticks. Ticks were collected throughout the year from domestic goats even when they were not collected in pastures.

Introduction

Tick-borne diseases are becoming more of a concern in the U.S. as humans, companion animals, and livestock are affected by various disease agents transmitted by different tick species (Hairgrove et al. 2014, Biggs et al. 2016, Modarelli et al. 2019). The south-central U.S. has many cases of human tick-borne diseases like spotted fever group rickettsiosis and ehrlichiosis (Drexler et al. 2016, Nichols Heitman et al. 2016), including two tick-borne viruses (bourbon and heartland) (Savage et al. 2017, 2018). Historically, the region focused on impact of ticks on cattle (Drummond 1967, Semtner et al. 1971, Semtner and Hair 1973, Barnard 1981, Barnard et al. 1982, Koch 1988, Mount et al. 1993, reviewed by Noden 2016). In recent years, regional studies focused on changes in distribution (Barrett et al. 2015, Mitcham et al. 2017) and risk of exposure to ticks in pastures (Polito et al. 2013, Noden et al. 2022). There is critical need on the southern Great Plains to re-examine the ecology of tick vectors in relation to specific kinds of domestic livestock.

Livestock production is important for the economy of the U.S. (NASS 2017). While focus is on cattle production, domestic goats (2.7 million) are raised in all 50 states. Shift in goat production led to increased Extension programming and training (Cole et al. 2018), but knowledge of tick species that feed on goats in pastures is based on reports before 1951 when most domestic goats were produced in Texas (Hooker et al. 1912, Cooley and Kohls 1944, Bishopp and Trembley 1945, Eads and Hightower 1951). Subsequent studies found producers use domestic goats to clear brush to limit tick infestation on cattle in pastures (USDA APHIS 2012, Cole et al. 2018). But, domestic goats in the U.S. can be reservoirs for human pathogens (*E. ewingii*, Panola Mountain Ehrlichia, *Coxiella burnetii*), and ticks that feed on infected goats can become infected and transmit pathogens to other hosts (Loftis et al. 2008, Körner et al. 2020, Yessinou et al. 2022). Ticks that feed on goats in specific regions need to be understood because they are zoonotic reservoirs of spillover infection.

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Oklahoma is 5th in the U.S. for numbers of farm-raised domestic goats (NASS 2017). However, no studies evaluated tick species and life stages on domestic goats in Oklahoma. To address the information gap in literature, we developed a pilot study with aims to: 1) summarize historical reports of tick species from domestic goats in the U.S. and 2) collect ticks from goats and pastures to compare tick communities at two sites in eastern Oklahoma on five dates during the year.

Web of Science® (Thompson Reuters, New York) and Pubmed® (National Center for Biotechnology Information, Bethesda, MD) were used to create a file of publications on U.S.-based studies on ticks and domestic goats based on keywords [goats, ticks, United States, North America] and key researchers. Criteria included any peer-reviewed manuscript associated with the topic in the database. Every publication was vetted to ensure the reference was peer-reviewed. While every effort was made to account for all published papers, because of the variety of places where articles can be published and early dates for many, the search was not exhaustive.

Goat operations used in the study were chosen because of locations in eastern Oklahoma where ticks probably would be in the pasture habitat. One farm close to Ada, OK, had mainly open pasture with limited cross-timbers oak habitat while the other farm near Hulbert, OK, had open pasture and mixed oak habitat. Collections from domestic goats and pastures occurred five times in 2016 to coincide with main peaks for various tick species and life stages in Oklahoma. Collection at Ada ended in July because ticks were absent after three rounds. During each visit, 15 goats were randomly chosen, and their ears, heads, flanks, and stomachs inspected. The collection protocol was approved by the Institutional Animal Care and Use Committee at Oklahoma State University. During each visit, vegetation was sampled using flagging and CO^2 trapping (Noden et al. 2022). For both sites, 200-m transects were sampled in the pasture and tree line with two CO_2 traps put randomly in each habitat for 1 hour. After collection from animal or vegetation, ticks were put into separate tubes containing 70% EtOH. Pictorial keys (Keirans and Litwak 1989, Keirans and Durden 1998, Dubie et al. 2017) were used in the laboratory to identify all ticks to species, life stage, and sex. Statistical analysis focused on differences in tick species and abundance between goats and pasture habitat. A likelihood test (SAS JMP pro 15) was used to evaluate differences between ticks on vegetation and goats between sampling times. To evaluate differences between abundance of ticks on goats versus the pasture, numbers of infected ticks of each species were transformed by log10 to meet assumptions of normality and homogeneity of variance, and ANOVA was used to evaluate relationships between mean numbers of different stages of *Amblyomma americanum* (L.) (response variables) and goat/pasture.

Results

Historical records of ticks on domestic goats mainly exist in published literature before 1951 (Table 1). Based on available records, five genera and 11 species of ticks were reported from domestic goats in the U.S. Most locations were in Texas. Numbers, except one study that recorded 314 adult *A. mixtum* on one goat (Table 1), ranged between 1-73 ticks from an individual or a group of goats.

All ticks collected on goats and in the pasture were at the domestic goat farm at Hulbert, OK. Three species of ticks (n = 228) were collected from goats during sampling (Table 2). Most (n = 220, 96.5%) were three life stages of *A. americanum*. Adults were collected between March and July, nymphs between May and August, and larvae in July and August. One *Dermacentor variabilis* (Say) was collected on

Table 1. Tick Species, Life Stage, Range of Numbers Reported, and Location of Collection from Historical Records of Collections from Goats in the United States

Species	Life stage (# range)	Location	Source
Amblyomma americanum (L.)	L(1), N(7-73), A(3-41)	Texas	Hooker et al. 1912, Cooley & Kohls 1944, Bishopp & Trembley 1945
Amblyomma maculatum Koch	N(1), A(2-4)	Texas	Hooker et al. 1912, Bishopp & Trembley 1945
Amblyomma mixtum Koch	L, A(314)	Texas	Hooker et al. 1912, Cooley & Kohls 1944
Amblyomma triste Koch	A(1)	Texas	Mertins et al. 2010
Dermacentor andersoni Stiles	A(1)	N/A	Bishopp & Trembley 1945
Dermacentor nitens (Neumann)	N(1)	N/A	Bishopp & Trembley 1945
Dermacentor variabilis (Say)	A(1)	Texas	Hooker et al. 1912, Bishopp & Trembley 1945, Eads & Hightower 1951
Haemaphysalis leporispalustris Packard	L(1), N(1)	Texas	Bishopp & Trembley 1945, Eads & Hightower 1951
Ixodes scapularis Say	A(1)	N/A	Bishopp & Trembley 1945
Ixodes sculptus Neumann	A(1)	N/A	Bishopp & Trembley 1945
Otobius megnini (Dugès)	N(1)	Texas	Bishopp & Trembley 1945, Eads & Hightower 1951

Table 2. Summary of Ticks Collected from Goats and Pasture at Hulbert, Oklahoma during 2016

Tick	Life stage	Habitat	March	May	July	August	November	Total
Amblyomma americanum	Adult	Goat	1	16	11	0	0	28
		Pasture	3	5	0	0	0	8
	Nymph	Goat	0	20	1	28	0	49
		Pasture	0	6	3	1	0	10
	Larva	Goat	0	0	2	141	0	143
		Pasture	0	0	506	500	0	1,006
Dermacentor variabilis	Adult	Goat	0	0	0	1	0	1
Ixodes scapularis	Adult	Goat	0	0	0	0	7	7
	Total		4	47	523	671	7	1,252

one goat in August, while one *Ixodes scapularis* Say was removed from each of six goats in November. Only *A. americanum* (n = 1,024) was collected from vegetation, with most (98.2%) being larvae (Table 1). Overall, the likelihood of *A. americanum* adults (χ^2 = 21.99, df = 4, *P* = 0.0002), nymphs (χ^2 = 26.79, df = 4, *P* < 0.0001), and larvae (χ^2 = 30.56, df = 4, *P* < 0.0001) on goats differed by month, but only adults differed by month in pastures (χ^2 = 9.89, df = 4, *P* = 0.0423). While there was no significant difference between mean abundance of adult and nymphal *A. americanum* between habitats, abundance of larvae significantly differed on goats compared with pastures (*F* = 24.69, df = 1, *P* < 0.0003).

The study found a gap in knowledge of species and behaviors of ticks feeding on domestic goats in the U.S. Data from the pilot study showed goats in eastern Oklahoma exposed to different species of ticks throughout most of the year. Ticks were collected from goats at every sampling period even if ticks were not encountered in the pasture at that time of year. Overall, there was no significant difference in the likelihood of encountering ticks on goats, while likelihood in the pasture depended on the time of collection. Historical records and this study indicated ticks were more abundant on domestic goats than in pastures. This probably was because of grooming behavior (Koch 1988).

Ticks on U.S.-based domestic goats were recorded in literature since the early 1900s. However, studies were vague on locations of collections, with most recorded in Texas (Hooker et al. 1912, Cooley and Kohls 1944, Eads and Hightower 1951). With domestic goats raised in all 50 states (NASS 2017), there is a large gap in knowledge regarding species of ticks on domestic goats throughout most of the U.S. While most personnel providing information about ticks to domestic goat producers make inferences between knowledge of local ticks in pastures and other animals (Koch 1988, Talley 2019), results from this study demonstrated that ticks (*D. variabilis* and *I. scapularis*) on goats might not always be found in surrounding pastures. This could indicate that surveys based only on vegetation might miss tick species that impact well-being of domestic goats in each region. This might be important not only for the health of the goat but also for humans and other animals near goats. *Ehrlichia ewingii* and Panola Mountain Ehrlichia, two human pathogens, were cultured from infected domestic goats in the U.S (Loftis et al. 2008). Infection of goats by the two pathogens were infectious to ticks for 5 months. Direct contact with domestic goats is also a risk factor for Q fever in the U.S., a disease caused by *Coxiella burnetii*, accounting for 20% of human cases between 2000 and 2012 (McQuiston and Childs 2002, Dahlgren et al. 2015). The zoonotic pathogen can be acquired and excreted by different ticks (Körner et al. 2020, Yessinou et al. 2022) and was detected in *Amblyomma mixtum* Koch in Texas (Sanders et al. 2008). Recent invasion by *Haemaphysalis longicornis* Neumann in 15 states in the U.S. (Schappach et al. 2020), presence on goats in other countries (Heath et al. 1987), and competence for significant tick-borne pathogens (Kang et al. 2016) amplify the need to focus on the topic in goat communities throughout the U.S.

In conclusion, the study focused on need for increased surveillance in the growing domestic goat industry in America. While Oklahoma is fifth in the U.S. for domestic goat production (NASS 2017), this is the first time a study monitored ticks on goats in pastures during a year. Grooming behavior of goats significantly reduces ticks, with restrained goats having 77 times more ticks than unrestrained goats (Koch 1988). That several tick species were collected throughout the year and domestic goats play a zoonotic role as reservoirs for several human tick-borne pathogens indicate more attention is needed in this sector of the livestock market.

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References Cited

Barnard, D. R. 1981. *Amblyomma americanum*: comparison of populations of ticks free living on pasture and parasitic on cattle. Ann. Entomol. Soc. Am. 74: 507-511.

Barnard, D. R., B. G. Jones, and G. D. Rogers. 1982. Sites of attachment of *Amblyomma americanum* to cattle. Ann. Entomol. Soc. Am. 75: 222-223.

Barrett, A. W., B. H. Noden, J. M. Gruntmeir, T. Holland, J. R. Mitcham, J. E. Martin, E. M. Johnson, and S. E. Little. 2015. County scale distribution of *Amblyomma americanum* (Ixodida: Ixodidae) in Oklahoma: addressing local deficits in tick maps based on passive reporting. J. Med. Entomol. 52: 269-273.

Biggs, H. M., C. B. Behravesh, K. K. Bradley, F. S. Dahlgren, N. A. Drexler, J. S. Dumler, S. M. Folk, C. Y. L. Kato, R. Ryan, M. L. Levin, and R. F. Massung. 2016. Diagnosis and management of tickborne rickettsial diseases: Rocky Mountain spotted fever and other spotted fever group rickettsioses, ehrlichioses, and anaplasmosis—United States: a practical guide for health care and public health professionals. MMWR 65: 1-44.

Bishopp, F. C., and H. L. Trembley. 1945. Distribution and hosts of certain North American ticks. J. Parasitol. 31: 1-54.

Cole, K. F., C. Hoegeman, B. M. Onyango, J. A. Pennington, C. A. Clifford-Rathert, and E. L. Walker. 2018. What extension personnel should know about midwestern goat producers. J. Extension. 56: 4RIB3.

Cooley, R. A., and G. M. Kohls. 1944. The genus *Amblyomma* (Ixodidae) in the United States. J. Parasitol. 30: 77-111.

Dahlgren, F. S., J. H. McQuiston, R. F. Massung, and A. D. Anderson. 2015. Q fever in the United States: summary of case reports from two national surveillance systems, 2000-2012. Am. J. Trop. Med. Hyg. 92: 247-255.

Drexler, N. A., F. S. Dahlgren, K. N. Heitman, R. F. Massung, C. D. Paddock, and C. B. Behravesh. 2016. National surveillance of Spotted Fever Group Rickettsioses in the United States, 2008-2012. Am. J. Trop. Med. Hyg. 94: 26-34.

Drummond, R. O. 1967. Seasonal activity of ticks (Acarina: Metastigmata) on cattle in southwestern Texas. Ann. Entomol. Soc. Am. 60: 439-447.

Dubie, T. R., R. Grantham, L. Coburn, and B. H. Noden. 2017. Pictorial key for identification of immature stages of common ixodid ticks found in pastures in Oklahoma. Southwest. Entomol. 42: 1-14.

Eads, R. B., and B. G. Hightower. 1951. Ectoparasites taken from Texas goats. J. Econ. Entomol. 44: 287.

Hairgrove, T. B., T. M. Craig, C. M. Budke, S. J. Rodgers, and R. J. Gill. 2014. Seroprevalence of *Anaplasma marginale* in Texas cattle. Prev. Vet. Med. 116: 188-192.

Heath, A. C. G., J. D. Tenquist, and D. M. Bishop. 1987. Goats, hares, and rabbits as hosts for the New Zealand cattle tick, *Haemaphysalis longicornis*. N. Z. J. Zool. 14: 549-555.
Hooker, W. A., F. C. Bishopp, and H. P. Wood. 1912. The life history and bionomics of some North American ticks (No. 106). US Dep. of Agric., Bur. Entomol.
Kang, J. G., S. Ko, W. B. Smith, H. C. Kim, I. Y. Lee, and J. S. Chae. 2016. Prevalence of *Anaplasma*, *Bartonella* and *Borrelia* species in *Haemaphysalis longicornis* collected from goats in North Korea. J. Vet. Sci. 17: 207-216.
Keirans, J. E., and L. A. Durden. 1998. Illustrated key to nymphs of the tick genus *Amblyomma* (Acari: Ixodidae) found in the United States. J. Med. Entomol. 35: 489-495.
Keirans, J. E., and T. R. Litwak. 1989. Pictorial key to the adults of hard ticks, family Ixodidae (Ixodida: Ixodoidea), east of the Mississippi River. J. Med. Entomol. 26: 435-448.
Koch, H. G. 1988. Suitability of white-tailed deer, cattle, and goats as hosts for the lone star tick, *Amblyomma americanum* (Acari: Ixodidae). J. Kans. Entomol. Soc. 61: 251-257.
Körner, S., G. R. Makert, K. Mertens-Scholz, K. Henning, M. Pfeffer, A. Starke, A. M. Nijhof, and S. Ulbert. 2020. Uptake and fecal excretion of *Coxiella burnetii* by *Ixodes ricinus* and *Dermacentor marginatus* ticks. Parasit. Vectors 13: 75.
Loftis, A. D., M. L. Levin, and J. P. Spurlock. 2008. Two USA *Ehrlichia* spp. cause febrile illness in goats. Vet. Microbiol. 130: 398-402.
McQuiston, J. H., and J. E. Childs. 2002. Q fever in humans and animals in the United States. Vector Borne Zoonotic Dis. 2: 179-191.
Mitcham, J. R., A. W. Barrett, J. M. Gruntmeir, T. Holland, J. E. Martin, E. M. Johnson, S. E. Little, and B. H. Noden. 2017. Active surveillance to update county scale distribution of four tick species of medical and veterinary importance in Oklahoma. J. Vector Ecol. 42: 60-73.
Modarelli, J. J., J. M. Tomeček, J. Piccione, P. J. Ferro, and M. D. Esteve-Gasent. 2019. Molecular prevalence and ecoregion distribution of select tick-borne pathogens in Texas dogs. Transbound. Emerg. Dis. 66: 1291-1300.
Mount, D. G. Haile, D. R. Barnard, and E. Daniels. 1993. New version of LSTSIM for computer simulation of *Amblyomma americanum* (Acari: Ixodidae) population dynamics. J. Med. Entomol. 30: 843-857.
NASS & USDA. 2017. Overview of U.S. livestock, poultry, and aquaculture production in 2017. https://www.aphis.usda.gov/animal_health/nahms/downloads/Demographics2017.pdf Accessed 31 October 2021.
Nichols Heitman, K., F. S. Dahlgren, N. A. Drexler, R. F. Massung, and C. B. Behravesh. 2016. Increasing incidence of Ehrlichiosis in the United States: a summary of national surveillance of *Ehrlichia chaffeensis* and *Ehrlichia ewingii* infections in the United States, 2008-2012. Am. J. Trop. Med. Hyg. 94: 52-60.
Noden, B. H. 2016. 'Where the wind comes sweeping down the plain': using a bibliometric study to identify trends and knowledge gaps of vector-borne disease research in Oklahoma. Southwest. Entomol. 41: 1175-1186.
Noden, B. H., T. R. Dubie, B. E. Henriquez, M. Gilliland, and J. L. Talley. 2022. Seasonality of ticks and prevalence of Rickettsiae species in *Dermacentor variabilis* and *Amblyomma maculatum* across Oklahoma pastures. J. Med. Entomol. 59: 1033-1041.

Polito, V. J., K. A. Baum, M. E. Payton, S. E. Little, S. D. Fuhlendorf, and M. V. Reichard. 2013. Tick abundance and levels of infestation on cattle in response to patch burning. Rangeland Ecol. Man. 66: 545-552.

Sanders, D. M., J. E. Parker, W. W. Walker, M. W. Buchholz, K. Blount, and J. L. Kiel. 2008. Field collection and genetic classification of tick-borne Rickettsiae and Rickettsiae-like pathogens from South Texas: *Coxiella burnetii* isolated from field-collected *Amblyomma cajennense*. Ann. N.Y. Acad. Sci. 1149: 208-211.

Savage, H. M., K. L. Burkhalter, M. S. Godsey Jr., N. A. Panella, D. C. Ashley, W. L. Nicholson, and A. J. Lambert. 2017. Bourbon virus in field-collected ticks, Missouri, USA. Emerg. Infect. Dis. 23: 2017-2022.

Savage, H. M., M. S. Godsey Jr., J. Tatman, K. L. Burkhalter, A. Hamm, N. A. Panella, A. Ghosh, and R. K. Raghavan. 2018. Surveillance for heartland and bourbon viruses in eastern Kansas. June 2016. J. Med. Entomol. 55: 1613-1616.

Schappach, B. L., R. K. Krell, V. L. Hornbostel, and N. P. Connally. 2020. Exotic *Haemaphysalis longicornis* (Acari: Ixodidae) in the United States: biology, ecology, and strategies for management. J. Int. Pest Man.11: 21.

Semtner, P. J., and J. A. Hair. 1973. The ecology and behavior of the lone star tick (Acarina: Ixodidae). IV. The daily and seasonal activity patterns of adults in different habitat types. J. Med. Entomol. 10: 337-344.

Semtner, P. J., R. W. Barker, and J. A. Hair. 1971. The ecology and behavior of the lone star tick (Acarina: Ixodidae). II. Activity and survival in different ecological habitats. J. Med. Entomol. 8: 719-725.

Talley, J. 2019. External Parasites of Goats. Oklahoma State Extension Fact Sheets. https://extension.okstate.edu/fact-sheets/external-parasites-of-goats.html Accessed 25 February 2022.

USDA APHIS. 2012. U.S. Meat Goat Operations. https://www.aphis.usda.gov/animal_health/nahms/goats/downloads/goat09/Goat09_is_MeatGoatOps_1.pdf Accessed 25 February 2022.

Yessinou, R. E., M. S. Katja, N. Heinrich, and S. Farougou. 2022. Prevalence of *Coxiella*-infections in ticks - review and meta-analysis. Ticks Tick Borne Dis. 13: 101926.