Knowledge, Attitudes, and Practices Regarding Ticks, Tick-borne Pathogens, and Tick Prevention among Beef Producers in Oklahoma

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Abstract. Tick-borne diseases are increasing in the United States, with regional need to understand how knowledge of ticks translates into preventative behavior among specific occupational groups. Little is known regarding what livestock producers know about ticks and their perceived personal and herd-based risk despite being one of the largest agro-industries in the United States. Using a nonprobability convenience sampling protocol, 183 beef producers representing 65% of the counties in Oklahoma completed a 15-question survey focused on knowledge of ticks and perceived risks ticks pose to their cattle and themselves, their methods of prevention (personal and their cattle), and sources of information. Most producers thought ticks were not a major problem for their cattle (58%), themselves, their families, and those who worked for them (66%). Most were personally concerned about spotted fever group rickettsiosis (79%) but had never heard of ehrlichiosis (9%). Eighty-five percent used at least one type of personal protective behavior, and 86% used at least one source of information for issues with ticks on their cattle. As the first published tick-focused survey involving livestock producers in the United States, it is apparent that beef producers in the central region are cognizant of ticks on their cattle and perceive ticks to be a risk on some level. However, increasing their knowledge of all areas of ticks and tick-borne pathogens, especially preventative measures for humans and cattle, is needed.

Introduction

Vector-borne diseases are increasing in the United States, led by tick-borne diseases, with different populations at risk of exposure (Rosenberg et al. 2018). The increased attention to tick-borne diseases has surveyed the knowledge, attitudes, and practices of different populations in various regions (Heller et al. 2010, Bayles et al. 2013, Hook et al. 2015, Butler et al. 2016, Gupta et al. 2018). With more focus on outdoor-focused occupations, knowledge, attitudes, practices, and serological surveys demonstrated that national park employees were three to 10 times more likely than the general public to be infected with a tick-borne disease (Adjemian et al. 2012, Eisen et al. 2013, Han et al. 2014). To date, limited attention has been given to livestock producers, an occupation involving long periods of outdoor work, particularly with cattle.

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Livestock producers are involved in one of the largest industries in the United States. Cattle generate 19% of all annual agricultural revenue, amounting to $76.4 billion in the United States (USDA 2015). In Oklahoma, 5.1 million cattle were raised on 52,000 farms in 2017 (OkDAFF 2017). US-based studies of knowledge, attitudes, and practices in the livestock sector have focused on biosecurity (Hoe and Ruegg 2006), worker safety (Sorge et al. 2014), and bird-livestock interactions (Shwiff et al. 2012), but not on the impact of ticks on professional and personal lives of producers. This cohort needs to focus on the health of their herds, considering effects of ticks on herd health (Williams et al. 1977, Stacey et al. 1978, Edwards et al. 2011) and increase in the incidence of bovine anaplasmosis in the US (Hanzlicek et al. 2016), as well as health risks involved with regional tick-borne diseases. The aim of this exploratory study was to better understand attitudes and knowledge of beef producers in Oklahoma in regard to ticks and risks they pose to their cattle and themselves, their methods of prevention both personal and on their cattle, and where they obtain information.

Materials and Methods

A questionnaire was administered to beef producers across the state of Oklahoma between August 2015 and April 2016. Nonprobability convenience sampling was used to access information from as many producers as possible. Paper-based surveys were administered by county extension agents at extension meetings, Oklahoma State University-directed 'cow-calf boot camps', and meetings of professional beef producers. The protocol for the study was approved by the Oklahoma State University Institutional Review Board. Participation was voluntary and oral informed consent was obtained from each participant. Producers who did not attend meetings and meeting participants under the age of 18 were excluded from the sample. Almost all responses were from cattle producers involved in cow/calf operations. Determining adequate sample size at a 99% confidence level and a 10% confidence interval based on the 51,000 producers in Oklahoma (OkDAFF 2017), more than 166 surveys were needed for a representative sample of those very involved in outdoor work and at risk of direct exposure to ticks by themselves, family members, and their cattle.

The questionnaire consisted of 15 questions (Pike 2017). The questions were multiple-choice (n = 6), multiple-choice with at least one write-in option (n = 4), and open-ended questions (n = 5). The questions were designed to capture data such as location, production type, perception of ticks as a problem, perceived risks of ticks, tick bite preventive behaviors, tick biology, source of information, and follow-up opportunity. A pilot survey with 32 participants involved in cattle production identified possible deficiencies with wording of questions and identified frequent responses to open-ended questions to modify multiple-choice responses for coding. To maintain internal validity within the study, three survey questions had an answer indicating the respondent did not have ticks on cattle. If the respondents were consistent with answers throughout the survey, the answers indicating lack of ticks should be consistent for the three questions. All data from surveys of producers was transferred to spreadsheets created in Excel 13 (Microsoft Office).

Results

Of 198 surveys returned, 183 were analyzed for the study after removal of surveys with missing information. Of the surveys received, 50 (65%) Oklahoma counties were represented by a producer with cattle in that county, with most from southern areas [Northeast (n = 31), Southeast (n = 68), Southwest (n = 62), and Northwest (n = 22)]. Most respondents (including those with multiple production types) had cow/calf operations (97.8%), while others had stocker operations (15.3%), seed stock operations (3.8%), learners (1.1%) including producers starting beef production operations, or 'other' operation types (5.5%) that included heifer development and multispecies operations including sheep and horses.

Only 19 (10.4%) of the producers across Oklahoma considered ticks to be a serious problem on cattle. Most producers thought ticks were not a serious problem, with 18% responding that ticks were not a problem at all and 3% responding that they had never thought about tick issues on their cattle (Table 1). One hundred five (57.4%) responded to an open-ended question of their concerns about tick infestations on their cattle.

Table 1. Perceptions of Oklahoma-based Cattle Producers (n = 183) regarding Risk of Ticks and Tick-borne Diseases in Cattle and Personal Knowledge of Tick-cattle Interactions. All questions were single-option answers unless mentioned.

Are ticks a problem on your cattle?	
Not a problem	33 (18.0%)
Somewhat a problem	68 (37.2%)
Moderate problem	58 (31.7%)
Serious problem	19 (10.4%)
Never thought about it	5 (2.7%)
What concerns you most about ticks on your cattle?	
Disease or ticks (incl ear ticks)	50 (27.3%)
Herd health (incl weight gain/loss)	37 (20.2%)
Anaplasmosis by name	15 (8.2%)
Other (tick fever or West Nile virus)	3 (1.6%)
No answer	78 (42.6%)
What month do you first notice ticks on your cattle?	
Jan – Mar	26 (14.2%)
Apr	41 (22.4%)
May	47 (25.7%)
June – Sept	31 (16.9%)
Year round	4 (2.2%)
No ticks	24 (13.1%)
No answer	10 (5.5%)
Where on the cattle do you normally see ticks*?	
No ticks	22 (12.0%)
Ear (combined – inner, base, outside)	104 (56.8%)
Head Region (ears and head)	105 (57.4%)
Lower front body (shoulder, neck, dewlap, brisket, foreleg, foreflank)	55 (30.1%)
Lower back body (Side, belly, rearflank, udder, rearleg)	60 (32.8%)
Upper back body (back, rump, tailhead, tail, escutcheon)	90 (49.2%)

*multiple options available

More than a quarter (27%) of the responses focused on diseases and/or tick issues in general, including ear ticks, while 20% were focused on how ticks impacted herd health (weight gain/loss). Fifteen producers mentioned anaplasmosis by name, while three focused on specific diseases such as 'tick fever' or West Nile virus. Asked when they first noticed ticks on their cattle, almost half of the producers reported seeing ticks on their cattle in April and May (Table 1). Provided a diagram of a cow, most respondents observed ticks in the head region, primarily on the ears, and on the upper back region, primarily at the tailhead.

Most (66.1%) of the producers thought ticks posed a low threat to themselves, their families, and those who worked for them. While only 10% believed ticks were a serious problem, almost a quarter thought ticks were not a problem for themselves, their families, and/or workers (Table 2).

Probed further, most respondents were concerned about Rocky Mountain spotted fever, followed by anaplasmosis (Table 2). Less than 10% of respondents identified ehrlichiosis as a risk, while 21 and 5% expressed concerned for West Nile virus and Lyme disease, respectively.

Of the producers surveyed, 84.7% (n = 155) used at least one type of personal protective behavior (Table 3). While 40.4% (n = 74) used one type of personal protection against ticks, 44.3% (n = 81) used two (n = 43) or three (n = 38) types of protection. Most (67%) indicated they checked their body after leaving the field, while half used some form of chemical protection. Of those surveyed, 92.3% (n = 169) used at least one method to treat their cattle for ticks; 33.3% (n = 61) responded they used only one method of tick control when asked an open question, while 50.2% used two (n = 59) or three (n = 33) methods. Most (67%) used a pour-on, while insecticidal sprays and ear-tags and injectable de-wormers also were used. Other forms used for control involved cattle rubs/rubbers, vet gun, medicated mineral, pasture burning, and birds. Of those surveyed, 86.3% used at least one source of information for tick issues on their cattle, with most using one (58.5%) or two (23.5%) sources. Other sources included OSU Extension offices, The Noble Foundation, family and neighbor ranchers, industry information, local business such as the feed store or sale barn, personal experience, and printed media such as magazines (Stuart Farm & Ranch). Asked what information producers would like to receive, 33.9% (n = 62) responded

Table 2. Perception of Oklahoma-based Cattle Producers (n = 183) regarding Personal Risk for Exposure to Ticks and Tick-borne Pathogens
All questions are single-option answers unless mentioned.

Are ticks a problem for you, your family, or your employees?	
Not a problem	44 (24.0%)
Somewhat a problem	77 (42.1%)
Moderate problem	42 (23.0%)
Serious problem	19 (10.4%)
Never thought about it	1 (0.5%)
What concerns you most about ticks on yourself, your family, or your employees*?	
Ehrlichiosis	17 (9.3%)
Rocky Mountain spotted fever	144 (78.7%)
West Nile virus	38 (20.8%)
Lyme	9 (4.9%)
Other (tick fever)	1 (0.5%)

*each disease is single response

Table 3. Cattle Producer Knowledge of Tick Protection Methods (Personal and Cattle) and Information Sources (n = 183)

What methods are used to protect from ticks*?	
No protection used	28 (15.3%)
Check body for ticks after leaving field	123 (67.2%)
Clothing barrier (pants tuck, long sleeves)	60 (32.8%)
Chemical protection	92 (50.3%)
*each method is single response	
What methods are used to treat cattle to prevent or reduce tick infestations*?	
Spray	67 (36.6%)
Pour-on	123 (67.2%)
Insecticidal ear-tags	59 (32.2%)
Dusts	14 (7.7%)
Injectable de-wormers	55 (30.1%)
Other	26 (14.2%)
*each method is single response	
What are your sources of information about ticks on your cattle*?	
Veterinarian	84 (45.9%)
Extension specialist	80 (43.7%)
Industry representative	13 (7.1%)
Internet resources	29 (15.8%)
Other – Extension OSU	24 (31.1%)
*each source is single response	

with five categories: any information (n = 8), education materials (n = 6), tick treatment and prevention methods (n = 31), human health concerns (n = 3), and disease and wellness in cattle (n = 14).

Discussion

Farmers and livestock producers have been identified as an occupational group at high risk for exposure to ticks and tick-borne pathogens (Piacentino and Schwartz 2002, De Keukeleire et al. 2016, Zając et al. 2017, Li et al. 2018), yet little is published regarding what they know about ticks, tick-borne pathogens, and how ticks affect their livestock. To our knowledge, this is the first published survey that focused on what US-based livestock producers know about ticks, their assessment of risk for themselves and their cattle, and what they are doing to mitigate the perceived problem in this important industry. Although limited in sample size and methodology, this exploratory study highlights particular areas in this under-studied occupation that need attention.

Most (67%) of the producers did not think ticks and tick-borne pathogens were a moderate or serious personal problem for themselves, their families, or farm workers. Additionally, most (58%) knew ticks were on their cattle but did not think they were much of a problem for the animals. This is concerning for the occupational health of livestock producers in the region. Recently, farmers in the central United States experienced the first fatal cases of heartland virus (Savage et al. 2013, McMullan et al. 2012) and bourbon virus (Kosoy et al. 2015) and were very likely to be impacted by spotted fever group rickettsiosis and ehrlichiosis through outdoor

activities (Biggs et al. 2016). The relatively large proportion of producers that recognized spotted fever group rickettsiosis as a concern in Oklahoma was encouraging, considering increases in spotted fever group rickettsiosis (Biggs et al. 2016) and ehrlichiosis (Springer and Johnson 2018) during the last 15 years. Lack of recognition of ehrlichiosis was probably because of the relatively recent introduction of the pathogen into Oklahoma in the late 1990s and increasing movement of the disease across the state in a westerly direction as the vector, *A. americanum*, invaded new areas (Barrett et al. 2015, Springer and Johnson 2018).

Among the interesting responses to the study, several components need further study. West Nile virus, which is not a tick-borne pathogen, was included in the survey after responses to the pilot study indicated it was a concern for producers. Whether producers considered it a tick-borne pathogen is questionable because the individual question was not tick-specific. Being cattle producers, they probably were familiar with cases of West Nile virus and its impact on horses in Oklahoma and might have interpreted the question to mean any disease of concern, including animals. Additionally, while responses were few (<5%), more work is needed to learn where producer concerns regarding Lyme disease originate because it does not occur in Oklahoma (Dubie et al. 2018, CDC 2019).

Limited awareness of risks of ticks and tick-borne pathogens probably reduced producer attention to preventative behaviors, both personal and cattle-related. It was encouraging that two-thirds of the respondents reported checking for ticks after outside activity and 50% claimed to use some kind of chemical protection. The responses were similar to surveys of residents in the US and other parts of the world (Bayles et al. 2013, Aenishaenslin et al. 2015, Kisomi et al. 2016). Preventative measures on cattle did not fare better, with only two-thirds of respondents using pour-on, with low rates of other preventive measures. While some attention seemed to be given to prevention, it was not possible to infer the quality of the preventive measures or any involving use of specific chemical preventatives.

In conclusion, the survey highlights that beef producers in Oklahoma are cognizant of tick infestations on their cattle and perceive ticks to be a risk on some level, but educational initiatives are needed to address personal protective behaviors as well as ways to monitor tick infestations on cattle. Lack of knowledge regarding ticks as vectors of human diseases might have played a part in lack of personal protection. However, addressing a knowledge deficit alone might not be sufficient. Focus on where producers are obtaining information, and working with veterinarians, public health authorities, and local extension personnel to improve the kind of education would provide correct knowledge of ticks and tick-borne diseases as well as effective methods for prevention.

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References Cited

Adjemian, J., I. B. Weber, J. McQuiston, K. S. Griffith, P. S. Mead, W. Nicholson, A. Roche, M. Schriefer, M. Fischer, O. Kosoy, J. J. Laven, R. A. Stoddard, A. R. Hoffmaster, T. Smith, D. Bui, P. P. Wilkins, J. L. Jones, P. N. Gupton, C. P. Quinn, N. Messonnier, C. Higgins, and D. Wong. 2012. Zoonotic infections among employees from Great Smoky Mountains and Rocky Mountain National Parks, 2008-2009. Vector Borne Zoonotic Dis. 12: 922-931.

Aenishaenslin, C., P. Michel, A. Ravel, L. Gern, F. Milord, J. P. Waaub, and D. Bélanger. 2015. Factors associated with preventive behaviors regarding Lyme disease in Canada and Switzerland: a comparative study. BMC Public Health 15: 185.

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* in Oklahoma: addressing local deficits in tick maps based on passive reporting. J. Med. Entomol. 52: 269-273.

Bayles, B. R., G. Evans, and B. F. Allan. 2013. Knowledge and prevention of tick-borne diseases vary across an urban-to-rural human land-use gradient. Ticks Tick Borne Dis. 4: 352-358.

Biggs, H. M., C. B. Behravesh, K. K. Bradley, F. S. Dahlgren, N. A. Drexler, J. S. Dumler, S. M. Folk, C. Y. Kato, R. R. Lash, M. L. Levin, R. F. Massung, R. B. Nadelman, W. L. Nicholson, C. D. Paddock, B. S. Pritt, and M. S. Traeger. 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.

Butler, A. D., T. Sedghi, J. R. Petrini, and R. Ahmadi. 2016. Tick-borne disease preventive practices and perceptions in an endemic area. Ticks Tick Borne Dis. 7: 331-337.

De Keukeleire, M., A. Robert, B. Kabamba, E. Dion, V. Luyasu, and S. O. Vanwambeke. 2016. Individual and environmental factors associated with the seroprevalence of *Borrelia burgdorferi* in Belgian farmers and veterinarians. Inf. Ecol. Epidemiol. 6: 32793.

Edwards, K. T., A. S. Varela-Stokes, C. D. Paddock, and J. Goddard. 2011. Gotch ear in a goat: a case report. Vector-Borne Zool. Dis. 8: 1217-1219.

Eisen, L., D. Wong, V. Shelus, and R. J. Eisen. 2013. What is the risk for exposure to vector-borne pathogens in United States national parks? J. Med. Entomol. 50: 221-230.

Gupta, S., P. Eggers, A. Arana, B. Kresse, K. Rios, L. Brown, L. Sampson, and M. Kploanyi. 2018. Knowledge and preventive behaviors towards tick-borne diseases in Delaware. Ticks Tick Borne Dis. 9: 615-622.

Han, G. S., E. Y. Stromdahl, D. Wong, and A. C. Weltman. 2014. Exposure to *Borrelia burgdorferi* and other tick-borne pathogens in Gettysburg National Military Park, South-Central Pennsylvania, 2009. Vector Borne Zoonotic Dis. 14: 227-233.

Hanzlicek, G. A., R. K. Raghavan, R. R. Ganta, and G. A. Anderson. 2016. Bayesian space-time patterns and climatic determinants of bovine anaplasmosis. PLoS One. 11: e0151924.

Heller, J. E., E. Benito-Garcia, N. E. Maher, L. B. Chibnik, C. P. Maher, and N. A. Shadick. 2010. Behavioral and attitudes survey about Lyme disease among a Brazilian population in the endemic area of Martha's Vineyard, Massachusetts. J. Immigr. Minor. Health 12: 377-383.

Hoe, F. G. H., and P. L. Ruegg. 2006. Opinions and practices of Wisconsin dairy producers about biosecurity and animal well-being. J. Dairy Sci. 89: 2297-2308.

Hook, S. A., C. A. Nelson, and P. S. Mead. 2015. U.S. public's experience with ticks and tick-borne diseases: results from national HealthStyles surveys. Ticks Tick Borne Dis. 6: 483-488.

Kisomi, M. G., L. P. Wong, S. T. Tay, A. Bulgiba, K. Zandi, K. L. Kho, F. X. Koh, B. L. Ong, T. Jaafar, and Q. N. H. Nizam. 2016. Factors associated with tick bite preventive practices among farmworkers in Malaysia. PLoS ONE. 11: e0157987.

Kosoy, O. I., A. J. Lambert, D. J. Hawkinson, D. M. Pastula, C. S. Goldsmith, D. C. Hunt, and J. E. Staples. 2015. Novel Thogotovirus associated with febrile illness and death, United States, 2014. Emerg. Inf. Dis. 21: 760-764.

Li, S., L. Juhász-Horváth, A. Trájer, L. Pintér, M. D. A. Rounsevell, and P. A. Harrison. 2018. Lifestyle, habitat and farmers' risk of exposure to tick bites in an endemic area of tick-borne diseases in Hungary. Zoonoses Public Health 65: e248-e253.

McMullan, L. K., S. M. Folk, A. J. Kelly, A. MacNeil, C. S. Goldsmith, M. G. Metcalfe, B. C. Batten, C. G. Albariño, S. R. Zaki, P. E. Rollin, W. L. Nicholson, and S. T. Nichol. 2012. A new phlebovirus associated with severe febrile illness in Missouri. N. Engl. J. Med. 367: 834-841.

OkDAFF (Oklahoma Department of Agriculture, Food and Forestry) and National Agricultural Statistics Service. 2017. Oklahoma Agricultural Statistics, 2017. https://www.nass.usda.gov/Statistics_by_State/Oklahoma/Publications/Annual_Statistical_Bulletin/ok_bulletin_2017.pdf. Accessed 21 August 2019.

Piacentino, J. D., and B. S. Schwartz. 2002. Occupational risk of Lyme disease: an epidemiological review. Occup. Environ. Med. 59: 75-84.

Pike, K. 2017. Responses of the Gulf Coast Tick to odorants to enhance field collection and a knowledge, attitude and practices survey of ticks with Oklahoma beef producers. MS thesis, Oklahoma State University, Stillwater, OK. https://shareok.org/handle/11244/49141. Accessed 1 June 2019.

Rosenberg, R., N. P. Lindsey, M. Fischer, C. J. Gregory, A. F. Hinckley, P. S. Mead, G. Paz-Bailey, S. H. Waterman, N. A. Drexler, G. J. Kersh, H. Hooks, S. K. Partridge, S. N. Visser, C. B. Beard, and L. R. Petersen. 2018. Vital signs: trends in reported vectorborne disease cases - United States and territories, 2004-2016. MMWR 67: 496-501.

Savage, H. M., M. S. Godsey, A. Lambert, N. A. Panella, K. L. Burkhalter, J. R. Harmon, R. R. Lash, D. C. Ashley, and W. L. Nicholson. 2013. First detection of heartland virus (Bunyaviridae: Phlebovirus) from field collected arthropods. Am. J. Trop. Med. Hyg. 89: 445-452.

Shwiff, S. A., J. C. Carlson, J. H. Glass, J. Suckow, M. S. Lowney, K. M. Moxcey, B. Larson, and G. M. Linz. 2012. Producer survey of bird-livestock interactions in commercial dairies. J. Dairy Sci. 95: 6820-6829.

Sorge, U. S., C. Cherry, and J. B. Bender. 2014. Perception of the importance of human-animal interactions on cattle flow and worker safety on Minnesota dairy farms. J. Dairy Sci. 9: 4632-4638.

Springer, Y. P., and P. T. J. Johnson. 2018. Large-scale health disparities associated with Lyme disease and human monocytic ehrlichiosis in the United States, 2007-2013. PLoS One. 13: e0204609.
Stacey, B. R., R. E. Williams, R. G. Buckner, and J. A. Hair. 1978. Changes in weight and blood composition of Hereford and Brahman steers in drylot and infested with adult Gulf Coast ticks. J. Econ. Entomol. 71: 967-970.
USDA (U.S. Department of Agriculture, National Agricultural Statistics Service). 2015. 2012 Census of agriculture: Cattle industry highlights. ACH12-20. 1-4. https://www.agcensus.usda.gov/Publications/2012/Online_Resources/Highlights/Cattle/Cattle_Highlights.pdf. Accessed 1 June 2019.
Williams, R. E., J. A. Hair, and R. G. Buckner. 1977. Effects of the Gulf Coast tick on blood composition and weights of drylot Hereford steers. J. Econ. Entomol. 70: 229-233.
Zając, V., J. Pinkas, A. Wójcik-Fatla, J. Dutkiewicz, A. Owoc, and I. Bojar. 2017. Prevalence of serological response to *Borrelia burgdorferi* in farmers from eastern and central Poland. Eur. J. Clin. Microbiol. Infect. Dis. 36: 437-446.