Bovine anaplasmosis herd prevalence and management practices as risk-factors associated with herd disease status

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A B S T R A C T

Bovine anaplasmosis is a hemolytic disease of cattle caused by *Anaplasma marginale* which can cause anemia, adult mortality, abortion, and performance reduction. The objectives of this study were to estimate herd-level infection prevalence of bovine anaplasmosis in Kansas cow-calf herds and assess management practices associated with herd infection status. Licensed Kansas veterinarians were randomly selected and provided clientele to generate randomly selected participant herds. Blood samples were collected from 10 mature cows during processing of 925 herds between October 1, 2016 and March 1, 2017. A management survey was completed by 780 herd-owners. Sample status was determined by competitive enzyme-linked immunosorbent assay (cELISA); operations indicating vaccination for anaplasmosis were tested with *A.marginale*-specific polymerase chain reaction (PCR). Survey data underwent logistic regression analysis for calculation of odds ratios and confidence intervals. The herd-level prevalence was 52.5 % of cow-calf herds. Prevalence ranged from 19.1 % of herds in Western Kansas to 87.3 % of herds in Eastern Kansas. Vaccinated herds were more likely (OR = 2.38; CI = 1.16–4.85; $p = 0.02$) to be positive compared to non-vaccinated herds, and herds that utilized insecticide ear-tags were more likely to be positive (OR = 1.9; CI = 1.42–2.55; $p < 0.01$) compared to herds which do not. Operations that prescribe-burned 21–50 % and > 50 % of their pastures were more likely to be test positive, OR = 5.74 (CI = 3 .14–10.51; $p < 0.01$) and OR = 4.78 (CI = 2.33–10.17; $p < 0.01$), respectively, than operations that prescribe-burned < 20 % of their pastures. In summary, anaplasmosis is present across Kansas beef herds at varied prevalence levels and selected management practices were found to be associated with herd infection status.

1. Introduction

Bovine anaplasmosis is a hemolytic disease of cattle caused by the bacterium *Anaplasma marginale* which can cause adult mortality, abortion, weight loss, and a reduction in performance (Howden et al., 2010; Kocan et al., 2010, 2003). The disease is common throughout tropical and sub-tropical regions of the world having widespread economical significant distribution throughout much of the United States (Kocan et al., 2010, 2003). Transmission to susceptible animals occurs through a variety of mechanical vectors, such as flies and veterinary instruments, and biological vectors, such as some tick species (de la Fuente et al., 2003; Eriks et al., 1989; Ewing et al., 1997; Kuttler and Simpson, 1978; Lankester et al., 2006; Scoles et al., 2005; Stewart, 1979). Cattle that survive infection become persistently infected

carriers which serve as the reservoir for naïve bovines (Aubry and Geale, 2011). Due to the subclinical nature of persistently infected animals, some producers are unaware of the infection status of their herd. This unknown infection status can impair the ability of cattle producers and veterinarians to design Anaplasmosis control programs. Many studies have investigated the prevalence of *A. marginale* in several U.S. states, but no randomized study to assess statewide prevalence has been completed (Alderink and Dietrich, 1983; Hairgrove et al., 2015, 2014; Morley and Hugh-Jones, 1989; Utterback et al., 1972; Zaugg and Kuttler, 1985). The objective of this study was to estimate herd-level infection prevalence in cow-calf herds and assess management practices associated with herd infection status in Kansas.

2. Materials and methods

2.1. Study design

Kansas cow-calf herd number and herd size inventory estimates for each agricultural district, provided by the National Animal Statistics Service (NASS, 2012) were used to calculate the number of herds required to estimate agricultural district herd prevalence using an Ausvet EpiTools on-line calculation tool (Ausvet, 2016). Herd prevalence estimates entered into the program included 10 %, 20 %, and 30 % for the Western, Central, and Eastern districts, respectively.

Because a list of all cow-calf operations in Kansas was not available, a sampling frame of all Kansas licensed veterinarians in each district was used to enlist beef cattle herds into the study. Veterinarians practicing within each district were randomly selected to participate in the study using a random number generator from the Stata program (Stata version 14, 2016). The number of practitioners to include into the study was estimated assuming each veterinarian would have approximately 10 participating herds. Kansas State University veterinary students then contacted each randomly selected veterinarian. Those practitioners who stated they were not cow-calf veterinarians (e.g. small animal only, retired, industry, etc.) or not willing to participate, were eliminated from the study. Participating practitioners were asked to compose a list of 20 producers they believed would be interested in participating in the study, and whose herd contained at least 10 adult beef cows. The veterinarians were asked to assign each producer a unique number between 1 and 20. From the list of producer numbers for each practitioner, researchers selected herds to participate using a commercial random number program from Microsoft Excel (Excel, 2016). The veterinarians were then instructed to select 10 mature animals using a sampling strategy provided by the researchers. In this strategy, 10 head of the first 20 mature females processed were chosen for sampling in alternating fashion. At initiation of the study, the researchers performed a single coin-flip to select either the first or second mature cow through the working facility with which to start sampling. After the selection of either the first or second mature animal to start the selection, every other animal through the working facility was sampled until 10 total samples were collected.

2.2. Samples

Herd sampling was targeted during the period October 1, 2016 to March 1, 2017. The targeted period was selected to allow samples to be collected during other cow processing procedures (e.g. transrectal pregnancy diagnosis) and to reduce the possibility of recent vector transmission. The sample collection and survey portions of this study were conducted in accordance with the Kansas State University Institutional Animal Care and Use Committee protocol #3815. Practitioners were provided necessary supplies including syringes, needles, packing supplies, and shipping coolers by the researchers. Samples included blood collected by tail vein into a 10 ml serum tube (BD Vacutainer Glass Serum Tube, 10 ml) and a 3 ml whole blood tube containing ethylenediaminetetraacetic acid (EDTA) (BD Vacutainer Glass Whole Blood Tube, 3 ml) from each selected animal. Veterinarians were asked to refrigerate the samples immediately after collection and samples were submitted weekly to the Kansas State Veterinary Diagnostic Laboratory. Both serum and whole blood were stored at −20 °C.

2.3. Testing procedures

At the completion of the collection period, serum samples were delivered to a commercial laboratory for *A. marginale* competitive Enzyme Linked Immunosorbent Assay (cELISA) testing using the Anaplasma Antibody Test Kit version 2, (VMRD, Pullman, WA) Polymerase chain reaction (PCR) was completed at the Kansas State

College of Veterinary Medicine on whole blood samples from herds reporting the use of *A. marginale* vaccine.

2.4. Survey

A management survey was administered to each producer by the veterinarian at the time of sample collection. The survey contained 41 closed and 3 open-ended questions regarding herd demographics, biosecurity, health management, parasite management, pasture management, and anaplasmosis knowledge.

2.5. Statistical analysis

Data was entered into a commercial spreadsheet program (Excel, 2016) and evaluated for accuracy. All data was then imported for analysis into a commercial statistical software program (Stata, 2016). The outcome variable of interest for each operation was herd anaplasmosis infection status. Each independent variable was initially assessed in univariable models. Independent variables were retained for further analysis when the P-value for an unconditional association was ≤ 0.30. Variables that remained following the univariable analyses were entered into a multivariable model, and manual backward selection was used to select independent variables that were significantly ($P < 0.05$) associated with the outcome variable. Each variable that was not retained during the initial backward elimination process was later re-offered to the model to reassess significance and check for confounding. Any variable reoffered to the final model that was significant or resulted in a coefficient change greater than 20 % for any other variable was retained in the model. This process continued until no variables reoffered to the model were eligible for retention. Unique veterinarian number was retained in each model because it was considered to be a possible confounder. Odds ratios were chosen for the final model due to their fit with the study objectives to describe associations relative to reference measures at a point-in-time. The odds ratio (OR) represents the odds that an outcome will occur relative to a baseline or reference measure. In the present study, a positive OR represents an outcome is more likely to be found in a group compared with the reference outcome associated with a particular management practice, and a negative OR would indicate that an outcome is less likely to found when compared with the reference outcome. A 95 % confidence interval was used in the present study.

3. Results

The sampling frame included 1483 Kansas licensed veterinarians. A total of 164 licensed veterinarians participated in the study (Fig. 1). The number of veterinarian participants by NASS defined district averaged 18.2 (range 9–31). In total, 925 herds participated in the prevalence portion of the study, and 780 (84.3 %) participated in both the prevalence and survey portions of the study. The number of cow-calf
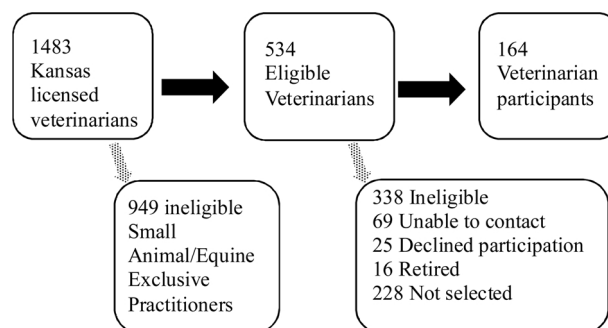

Fig. 1. Graphical demonstration of the randomization and selection of veterinarian participants from a sampling frame of licensed Kansas veterinarians.

Table 1
Number of participating veterinarians and cow-calf study herds in Kansas.

Agricultural District	Number of Veterinarians	Number of Herds	Surveys Completed
Northwest	12	121	108
North central	17	104	75
Northeast	29	101	86
West Central	9	73	69
Central	13	96	83
East central	31	121	91
Southwest	13	61	47
South central	18	153	141
Southeast	22	95	80
Study Total	164	925	780

Table 2
Anaplasmosis herd prevalence results by agricultural district with PCR results included.

Agricultural District	Seroprevalence	Vaccinated Herds	PCR-Positive Herds	PCR-Negative Herds Excluded
Northwest	19.8 %	2	0	18.1 %
North central	44.2 %	0	0	44.2 %
Northeast	78.2 %	3	2	77.2 %
West Central	19.2 %	2	0	16.4 %
Central	57.3 %	3	3	57.2 %
East central	76.9 %	7	6	76 %
Southwest	34.4 %	5	3	31.1 %
South central	46.4 %	4	2	45 %
Southeast	87.3 %	19	17	85.2 %
Overall	52.5 %	45	33	51.2 %

operations that participated in the study averaged 102.7 per district (range 61–153) (Table 1). The average number of sampled herds per veterinarian in each district ranged from 3.5 herds to 10.1 herds.

In total, 925 Kansas cow-calf operations (9250 mature cows) were sampled. Overall 52.5 % (486/925) of cattle herds were found to be *A. marginale* cELISA test positive. The largest test prevalence risks were found in the three eastern Kansas agricultural districts including 78.2 %, 76.9 %, and 87.4 % for the Northeast, East Central, and Southeast districts, respectively (Fig. 2). The smallest prevalence risks were found in the western districts and included 19.8 % in the Northwest, 19.1 % in the West Central, and 34.4 % in the Southwest districts. Central Kansas district prevalence risks were 44.2 %, 57.3 %, 46.4 % in the North Central, Central, and South Central districts, respectively (Fig. 2 and Table 2).

Of the sampled herds, 4.8 % (45/925) reported vaccinating for Anaplasmosis. Vaccination use was reported in each district except the North Central district, and 42 % (19/45) of herds indicating vaccine use were located in the Southeast district. Of the vaccinated herds 75.6 % (34/45) were cELISA positive and 73.3 % (33/45) were PCR positive. All vaccinated herds that were PCR positive were also cELISA positive, and one cELISA positive herd was PCR negative. Vaccinated herds found to be PCR positive were designated as infection positive herds for the multivariable model. The overall infection prevalence in the study was 51.7 % (474/925) (Table 2).

3.1. Survey results

Of the 925 sampled herds, 780 producers completed the accompanying management survey and were included in the risk analysis. The average reported herd size was 189 adult animals (range 10–2000). The respondent herd size frequencies are reported in Fig. 3 and the number surveys completed in each district are reported in Table 1. Breed composition included, 76 % (593/780) British influence, 7.2 % (56/780) Continental, and 14.6 % (111/780) mixed breeds. The operation types represented were 85.6 % (668/780) commercial, 3.2 % (25/780)

Fig. 2. Apparent prevalence estimates for the nine agricultural districts in Kansas.

purebred, and 11.1 % (87/780) were both types. Targeted calving period of the respondent herds included 74.4 % (583/780) spring calving (January–July), 2.7 % (21/780) fall calving (August–December), and 22.6 % (176/780) targeted both time periods. Of the respondents, 97.8 % (763/780) reported having a general vaccine program in place, and 96.2 % (756/780) indicated that their veterinarian was an advisor in the development of their vaccine program. Reported yearly vaccine use consisted of 12.7 % (99/780) of herds which used two or fewer vaccines and 77.3 % (681/780) herds which used three or more vaccines. Of the respondents, 2.6 % (20/780), 17.1 % (133/780), 33.1 % (258/780), 30.6 % (239/780), and 16.7 % (130/780) reported using 0, 1, 2, 3, or four or more parasiticides during the year. Thirty respondent producers (3.9 %) reported changing needles between every animal when administering injections to cattle during processing or treatment. Of the operations that implanted cattle, 15.9 % (124/780) indicated the implant gun was disinfected between each animal. Of the operations utilizing permanent tattoos, 6.0 % (47/780) reported disinfecting the tattoo gun before use on a subsequent animal. Of the operations that castrate bull calves, 35.4 % (276/780) banded at birth, 15.4 % (120/780) banded at weaning, and 57.1 % (445/780) castrated by knife, of which 49 % reported disinfecting the surgical tool between animals. Only 55.3 % (431/780) of the producers answered questions concerning chlortetrycline use. Chlortetracycline was reported to be used by 25.3 % (109/431) of respondents and 19.3 % (83/431) reported year-round use of chlortetracycline while 6.0 % (26/431) only used chlortetracycline in the spring and summer months.

Independent variables were assessed initially in a univariable analysis (Table 3). Variables from questions that were answered by < 5 % of the study participants were excluded from the analysis. These variables included diagnostic testing prior to new cattle entering the herd, type of cattle imported, and targeted consumption of chlortetracycline.

Several variables of interest were not associated (*P* > 0.30) with the outcome of interest. Herd characteristic variables such as breed (Continental, British, or British X Continental), herd type (cow-calf only, cow-calf with feeders, cow-calf with stockers), and operation type (commercial, registered, or both) were not associated with herd infection status for anaplasmosis. Origination of cattle from United States geographical regions Northeast, Southeast, North Central, South Central, Midwest, and West United States was not associated with anaplasmosis status of the Kansas cow herds. Health management variables such as disinfection of castration knife or implant gun, importation of cattle, or testing cattle for Anaplasmosis were not associated with herd infection status. Parasite control measures such as the inclusion of a mineral insect growth regulator, the use of an injectable dewormer, or the use of electronic direct fly control were not associated with cow herd anaplasmosis status.

The final multi-variable model included 3 variables associated with herd infection designation (*P* < 0.05) (Table 4). Compared with herds that do not use insecticide ear tags, herds which utilized insecticide ear
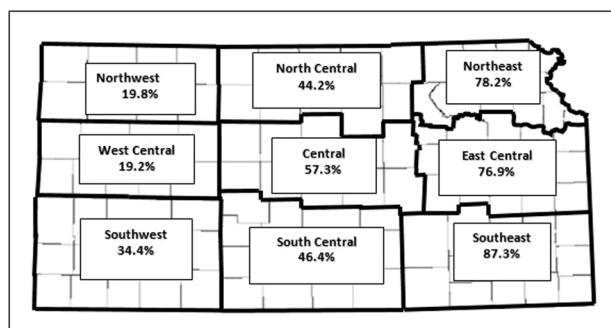
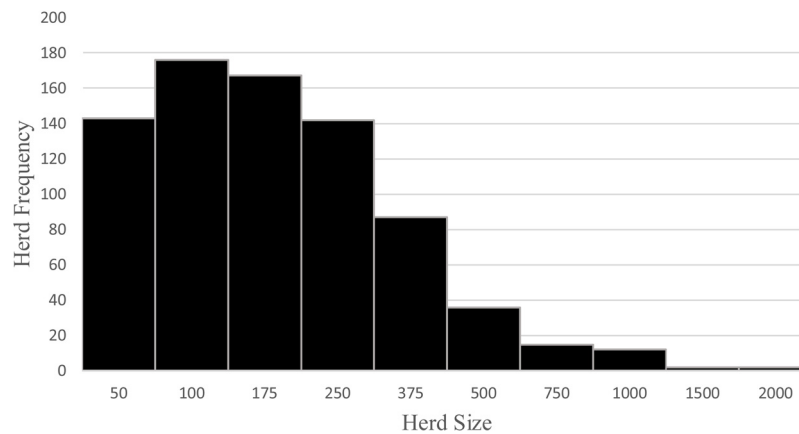## Herd size frequency of Kansas bovine anaplasmosis survey respondents

Fig. 3. Herd size frequency of Kansas Bovine Anaplasmosis survey respondents.

Table 3
Results of univariable logistic regression model indicating management practices that were associated ($P \leq 0.30$) with the bovine anaplasmosis herd infection status in 780 Kansas cow-calf operations from data obtained in survey.

Variable	P-value	OR	95 % CI of the OR
Herd size	0.03	0.87	0.77–0.99
See Ticks on your cattle	< 0.01	2.45	1.43–4.21
Disinfect castration knife	0.57	1.15	0.69–1.92
Disinfect dehorner	0.27	1.44	0.75–2.79
Disinfect ear notcher	0.22	1.45	0.79–2.65
Implant gun disinfected	0.40	0.78	0.43–1.41
Number of parasiticides used	0.05	1.14	1.00–1.29
Insecticide eartags used	< 0.01	2.53	1.87–3.41
Injectable dewormer used	0.92	0.98	0.63–1.53
Pour-on dewormer used	0.04	0.34	0.12–0.95
Mineral IGR	0.83	1.04	0.73–1.49
Backrub bags used	0.06	0.63	.40–1.01
Fog	0.05	1.61	1.00–2.60
Electronic zappers	0.31	0.47	0.11–2.05
Change needles	0.18	1.68	0.79–3.59
Vaccine advice	0.15	1.42	0.88–2.29
Test for anaplasmosis	0.96	1.03	0.31–3.38
Pasture use	0.23	1.20	0.89–1.62
Vaccinated	< 0.01	3.13	1.57–6.26
Import cattle	0.59	1.06	0.86–1.29
Use anaplas vaccine	< 0.01	3.72	1.58–8.77
Hay Purchase	0.13	0.85	0.69–1.05
Targeted calving	< 0.01	2.53	1.70–3.76
Operation type	0.58	1.09	0.79–1.50
Herd type	0.99	1.00	0.76–1.33
Pasture burn	< 0.01	3.08	2.05–4.64
Import region	0.19	0.59	0.26–1.32
Breed	0.69	1.05	0.84–1.31
District	0.01	1.17	1.04–1.31
Veterinarian	< 0.01	1.02	1.01–1.02
CTC use	< 0.01	1.83	1.34–2.48
Supplement hay	0.10	1.38	0.93–2.04
Number of vaccines	0.19	0.92	0.80–1.05

Table 4
Results of the multivariable logistic regression model indicating management practices that were associated ($P < 0.05$) bovine anaplasmosis herd infection status in 780 Kansas cow-calf operations using a survey.

Variable	P-value	Level	B	SE(B)	OR	95 % CI of the OR
Insecticide eartag	< 0.01	No				
		Yes	0.64	0.15	1.90	1.42–2.55
Use Anaplasma vaccine	0.02	No				
		Yes	0.87	0.36	2.38	1.16–4.85
Pasture burn	< 0.01	0–20 %				
		20–50 %	1.75	0.30	5.74	3.14–10.51
		> 50 %	1.58	0.37	4.87	2.33–10.17
Veterinarian	0.24		0.00	0.00	1.00	1.00–1.01

4. Discussion

According to Aubry and Geale, the prevalence of Bovine Anaplasmosis in the United States is largely unknown, and accuracy in published test prevalence or incidence reports is challenging because of the difficulties in executing population-based or random sampling (Aubry and Geale, 2011). The current study reported the percentage of tested herds positive for Anaplasmosis of 51.7 %. The present study was not a completely random sampling of Kansas herds, but was limited to the existing infrastructure of existing veterinary-client relationships in the state. Veterinarians were randomly selected to participate, but because they were asked to provide a list of producers who potentially would be willing to participate this may have injected bias into the study. It is plausible that only those producers who have a strong working relationship with the practitioner or utilize the practitioner for routine services (i.e. pregnancy examination) had the potential for participation. It is also possible veterinarians listed those herds that were suspected, but not confirmed, as Anaplasmosis positive (i.e. for Veterinary Feed Directive information) or listed herds familiar with and concerned about Anaplasmosis. Therefore these herds may or may not represent the average Kansas cow-calf operation. The prevalence estimate generated in the current study was likely affected by the study design's limitations concerning the ability to detect disease within each herd. The calculated herd sensitivity for sampling 10 mature cows in herds with lower within- herd prevalence may have resulted in some herds misclassified as negative. For instance, calculated herd sensitivity for herds with 10 % within-herd prevalence were 69 %, 67 %, 66 % for herd sizes of 50, 100, and 500, respectively (Ausvet, 2018). The prevalence estimates from most other studies sampled cattle within a state

tags were more likely to be anaplasmosis positive ($P < 0.01$). Herds which utilized an Anaplasma vaccine were more likely to be test positive ($P = 0.02$) compared with herds which do not vaccinate for the disease. Compared with herds which prescribe burn < 20 % of pastures, operations which prescribe-burn 20 %–50 % and operations which prescribe-burn greater than 50 % of pastures had increased risk ($P < 0.01$) of a positive herd status.

were on an individual and not herd basis. Utterback and others in 1969–1970 reported 43 % (3,519/8,156) of the cattle they tested were positive in California using the Complement Fixation test (Utterback et al., 1972). These samples were collected over separate periods during 1969 and 1970 and using a combination of serum collected at slaughter and practitioner submissions (Utterback et al., 1972). Kuttler and Zaugg in 1985 reported 12.6 % (1,283/10,167) individuals and 29.17 % (119/ 408) herds they sampled were infected in Idaho (Zaugg and Kuttler, 1985). These samples were collected over a period of two years and obtained the samples using a combination of serum from regulatory testing, practitioner submissions, and regularly sampled herds (Zaugg and Kuttler, 1985). Animals classified as positive for Anaplasmosis infection were positive on both Rapid Card Agglutination test and Complement Fixation test (Zaugg and Kuttler, 1985). Morely in 1985 reported 7.8 % (860/11,085) of individuals and 58.9 % (123/209) herds were test positive in Louisiana (Morley and Hugh-Jones, 1989). The samples in the study were from 14 parishes representing the Red River Plains areas and the Southeast area of Louisiana amounting to 29 % of the state's beef cow population and 76 % of the state's dairy cow population. Sample collection in the Morley study consisted of two serum banks collected under the state's Brucellosis Eradication Program during the years 1982 and 1984; testing was conducted using the Indirect Fluorescent Antibody test (Morley and Hugh-Jones, 1989). In 2014, Hairgrove and others reported a pooled apparent seroprevalence of 15.02 % using a commercial cELISA test in 1835 serum samples collected from 23 livestock auction markets across the state of Texas in July of 2011 (Hairgrove et al., 2014). More recently, in 2015, Hairgrove and others reported 40.1 % (174/434) of individual cattle they sampled in 11 Texas herds were test positive representing regions tested in their auction market study (Hairgrove et al., 2015). These studies' estimates may be limited by the lack of a random sampling study design. Many of the samples for these studies were obtained through the collection of serum for the surveillance of other diseases (Morley and Hugh-Jones, 1989; Utterback et al., 1972; Zaugg and Kuttler, 1985). Differences between those studies' estimates and the present study may be explained by the difference in targeted sampling populations, including management differences between dairy and beef operations, and practitioner involvement in sample collection. Additionally, some of the previous studies may have used diagnostic tests with poor diagnostic sensitivity and may have resulted in under-reporting true herd prevalence (Bradway et al., 2001; OIE, 2018).

The use of insecticide ear tags was the only parasite control method with statistical significance (OR = 1.9, $P < 0.01$) remaining in the final model indicating an association with herd infection designation. Interestingly no association was noted with herd infection with regard to the number of varied parasite control methods used. This finding could indicate that insecticide ear tag application shares a geographic distribution with areas of higher concentrations of anaplasmosis infected herds. It could also be that insecticide ear tags are commonly applied in areas of elevated ectoparasite burdens, and those ectoparasites contribute to the transmission of anaplasmosis and maintenance of positive herds in the region. Thus increased insecticide ear tag application may be a response to increased risk, and not necessarily infection status.

Whole-pasture prescribed burning and patch burning have been suggested to play a role in decreasing the number of ticks exposed to cattle (Polito et al., 2013). Although this study did not find an association between herd status and the presence of ticks in Kansas, Utterback and Zaugg both indicated the presence of this association in their respective studies in California and Idaho (Utterback et al., 1972; Zaugg and Kuttler, 1985). The investigators in the present study were interested in the frequency of burning as reflected by the percent of grazing area burned in the past three years. Compared with operations which had previously prescribe-burned 0–20 % of their pastures, operations which prescribe-burned 20–50 % and operations or prescribe-burned > 50 % of pastures were 5.74 and 4.78 times more likely to

have been test positive, respectively. These findings may be due to a distribution of prescribed-burning that is in more common in areas with heavy tick burdens; conversely the findings may be suggestive that pasture burning is not an effective method of tick control. A third plausible explanation to the increased likelihood of infection in areas where burning large areas is practiced includes the possibility these environmental conditions that influence the distribution of range burning also allow for an increased stocking density of livestock. Increased stocking density may also enhance the opportunities for transmission from infected to naïve animals and thereby increase disease prevalence as was found in the study by Utterback et al. (1972).

The current study had several opportunities for the injection of bias. Selection bias at the level of the researchers and the veterinarians was possible. Veterinarians were randomly selected to participate, but it is possible that only those veterinarians interested in the distribution of bovine anaplasmosis in their practice area participated. Likewise, producers who agreed to participate may have been motivated to discover the disease status of their herd. Recall bias was also possible in the completion of the survey because some questions asked about management practices occurred in the past. Additionally cooperator bias may have influenced the participant herds as their veterinary relationship may make them more likely to utilize a veterinarian, perhaps more interested in research, and more likely to utilize progressive management techniques.

5. Conclusion

The results of the current study reflect a wide distribution of Anaplasmosis across most Kansas agricultural districts. This study indicated that some management practices are associated with herd infection status, but many commonly promoted anaplasmosis management practices were not strongly associated with herd anaplasmosis infection. Further studies are needed to examine the economic impact and the molecular and pathogenic variants in the state and across the nation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Mark R. Spare: Conceptualization, Methodology, Resources, Formal analysis, Investigation, Data curation, Writing - original draft, Project administration. **Gregg A. Hanzlicek:** Conceptualization, Methodology, Resources, Formal analysis, Investigation, Writing - review & editing, Supervision. **Kotie L. Wootten:** Resources, Investigation, Data curation. **Gary A. Anderson:** Writing - review & editing, Resources, Funding acquisition. **Dan U. Thomson:** Writing - review & editing, Resources, Funding acquisition. **Michael W. Sanderson:** Conceptualization, Methodology, Writing - review & editing. **Roman R. Ganta:** Conceptualization, Methodology, Writing - review & editing. **Kathryn E. Reif:** Resources, Data curation, Writing - review & editing. **Ram K. Raghavan:** Conceptualization, Methodology, Writing - review & editing.

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