PEER REVIEWED

Herd Prevalence and Risk Factors of *Leptospira* Infection in Beef Cow/calf Operations in the United States: *Leptospira borgpetersenii* Serovar Hardjo

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Abstract

The herd prevalence of *Leptospira borgpetersenii* serovar Hardjo (hardjo-bovis) infection and associated risk factors were determined for beef cow/calf operations in California, Florida, Mississippi, Missouri, South Dakota and Texas. Three veterinary practitioners randomly selected in each state completed a questionnaire on herd management practices, and collected blood and urine from 10 to 15 cows in four randomly selected herds. Serums were tested for antibodies against leptospiral serovars Grippotyphosa, Hardjo, Icterohemorrhagiae and Pomona using the microscopic agglutination test. Urine sediments were stained with a non-serovar specific florescein-labeled anti-leptospira antibody conjugate. Herd infection with *L. borgpetersenii* serovar Hardjo was inferred if one or more cows had leptospires in their urine accompanied by either high antibody titers to the organism, or low titers to it and low titers against serovars Grippotyphosa, Icterohemorrhagiae and Pomona.

Twenty-eight (42%) of 67 herds had results compatible with infection with *L. borgpetersenii* serovar Hardjo. Herds in South Dakota had a significantly lower prevalence than herds in other states (P=0.01). A greater likelihood of infection with *L. borgpetersenii* serovar Hardjo was found in herds with higher mean annual temperatures (P=0.02) and longer breeding seasons (P=0.02). Altering risk factors that predispose herds to infection, such as shortening length of breeding season, should increase the effectiveness of programs to control this disease.

Keywords: bovine, beef, hardjo-bovis, leptospirosis

Résumé

La prévalence au niveau des troupeaux des infections causées par le sérotype Hardjo (hardjo-bovis) de *Leptospira borgpetersenii* de même que la prévalence des facteurs de risque qui lui sont associés ont été déterminées dans des élevages vaches-veaux de boucherie en Californie, en Floride, au Mississippi, au Missouri, au Dakota du Sud et au Texas. Trois vétérinaires praticiens choisis au hasard dans chacun des états ont complété un questionnaire sur la régie de troupeau et ont aussi recueilli des échantillons de sang et d'urine de 10 à 15 vaches dans quatre troupeaux choisis au hasard. Les sérums ont été testés pour la présence d'anticorps contre les sérotypes leptospiraux Grippotyphosa, Hardjo, Icterohemorrhagiae et Pomona avec un test de micro-agglutination. Les sédiments d'urine ont été colorés avec un conjugué d'anticorps antileptospiral non spécifique au sérotype et marqué avec la fluorescéine. L'infection dans un troupeau avec le sérotype Hardjo de *L. borgpetersenii* était présente si une ou plusieurs vaches avait des leptospires dans leur urine en parallèle avec soit des titres d'anticorps élevés contre cet organisme ou soit des titres peu élevés contre cet organisme et des titres peu élevés contre les sérotypes Grippotyphosa, Icterohemorrhagiae et Pomona.

Une infection compatible avec le sérotype Hardjo de *L. borgpetersenii* était présente dans 28 (42%) des 67 troupeaux. La prévalence au niveau des troupeaux était moins élevée au Dakota du Sud que dans les autres états (P = 0.01). L'infection avec le sérotype Hardjo de *L. borgpetersenii* était plus probable dans les troupeaux exposés à des températures moyennes annuelles plus élevées (P = 0.02) et lorsque la saison de reproduction était plus longue (P = 0.02). L'efficacité des programmes de contrôle de cette maladie pourrait s'accroître en modifiant les facteurs de risque qui prédisposent les troupeaux à l'infection comme par exemple une réduction de la durée de la saison de reproduction.

Introduction

Reproductive wastage due to infectious agents is a constant threat to the productivity and profitability of beef cow/calf operations. *Leptospira* belonging to serovar Hardjo have been associated with the entire gamut of reproductive losses in cattle. Serovar Hardjo was first isolated from cattle in the United States (US) in 1960 in Louisiana.[38] There are two distinct types of serovar Hardjo: *L. interrogans* serovar Hardjo (hardjoprajitno) and *L. borgpetersenii* serovar Hardjo (hardjo-bovis). There are significant genetic differences between these organisms, but only minor antigenic differences, making them virtually indistinguishable serologically.[26] Serovar Hardjo type hardjoprajitno is present in the United Kingdom and a few other locations but has not been identified in the US, whereas serovar Hardjo type hardjo-bovis (hereafter 'hardjo-bovis') is widespread in North America and other parts of the world.

Strong evidence has accumulated linking hardjo-bovis infection with reproductive losses in beef and dairy herds. Experimental infection of pregnant cattle with hardjo-bovis has resulted in abortions,[44] stillbirths[8] and weak calves.[8,44] There have been numerous reports in the North American veterinary literature associating natural infection with hardjo-bovis in beef or dairy herds with repeat breeders,[20,23] low pregnancy rates,[21] abortions,[23,35,37,41,42,44] stillbirths[23] and weak calves.[21,23,44] An atypical mastitis, characterized by flaccid udders and thick yellow milk, is sometimes seen in addition to reproductive losses in herds of cattle infected with hardjo-bovis.[21,23,35,42]

Veterinarians have traditionally associated leptospiral infection of cattle with abortion. Difficulties in diagnosis of leptospirosis, however, have resulted in inaccurately low estimates of infection rates by laboratories as a cause of abortion in the US[2,3,25] and Canada,[1] giving practitioners the false impression that leptospirosis was not a problem in their clients' herds. New approaches to diagnosis have implicated leptospiral infection as one of the most common infectious causes of bovine abortion. Leptospirosis (*L. pomona* and hardjo-bovis cases combined) was the third most common diagnosis in abortions of beef or dairy cattle in California investigated from 1998 to 2003.[2] Leptospirosis was diagnosed more frequently than bovine viral diarrhea virus, the fifth most common cause of abortion in that survey, which established an etiologic diagnosis in 44% of 2,296 abortions.

In addition to abortions, stillbirths and weak calves, infection of cattle by hardjo-bovis has been implicated in infertility.[14,20] Reproductive performance measures were monitored for first-lactation cows that were either seropositive (serum microscopic agglutination titer > 1:100) or seronegative (serum microscopic agglutination titer < or = 1:100) to hardjo-bovis within 40 days after calving on a California dairy.[20] Median time from calving to conception for seropositive cows (132.6 days) was significantly longer (P=0.026) than for seronegative cows (95.4 days), and services per conception for seropositive cows (3.4) were significantly higher (P=0.023 for cows with a titer < 1:100 and P=0.035 for cows with a titer of 1:100) than seronegative cows (2.1).

Serologic surveys utilizing microscopic agglutination titers (MAT) have repeatedly shown hardjo-bovis to be the most common serovar of leptospira affecting beef and dairy cattle in North America. In the US, seropositivity to hardjo-bovis predominated in samples collected from cattle at slaughter,[29,43,45,48] at auction,[40] or for analysis at a diagnostic laboratory.[32] The percentage of cull beef or dairy cows seropositive for hardjo-bovis varied from 10.8% of 204 cows originating from Iowa, Missouri and Illinois[45] to 29.4% of 5,111 cows in 49 states and Puerto Rico.[29] In the later study, leptospires were isolated from 88 (1.7%) of 5,142 kidneys, with 83% identified as hardjo-bovis.[29] Hardjo-bovis was isolated from the kidneys, and in some cases, the reproductive tract of five of 11 nonpregnant cows chosen at random from an Iowa slaughterhouse.[15] These surveys likely under represented the true levels of infection because cattle infected with hardjo-bovis may quickly become seronegative and leptospires are difficult to culture.

Hardjo-bovis has also emerged as the most common leptospiral infection of cattle in the Canadian provinces of Alberta,[22] British Columbia[24] and Quebec.[19] In Alberta, 8.3% of 18,147 cows tested for brucellosis had antibodies against hardjo-bovis.[22] In British Columbia, 15.4% of 1300 cull beef or dairy cows sold at auction, representing 163 herds, were seropositive for hardjo-bovis.[24] In Quebec, 77% of leptospiral isolates from nephritic kidneys of steers at slaughter were hardjo-bovis.[19]

Herd prevalences of hardjo-bovis have been estimated for dairies in the US[4] and Canada,[35] and beef cow/calf operations in Canada.[35] A diagnosis of herd infection with *Leptospira* (likely hardjo-bovis) was made in 26 of 44 (59%) dairies located in four dairying regions of the US.[4] Infected herds had one or more cows shedding leptospires in their urine plus patterns of serum titers to five leptospiral serovars compatible with infection with hardjo-bovis. In Ontario, 8.4% of 296 dairy herds and 44.2% of 52 beef herds not vaccinated against leptospirosis contained cows serologically positive for hardjo-bovis.[35]

Very efficient transmission of hardjo-bovis infection is responsible for its widespread occurrence in North American cattle. Cattle chronically infected with hardjo-bovis serve as maintenance hosts for spread to healthy cattle.[7] The organism localizes in kidneys and male or female reproductive tracts, and is directly shed to other cattle in urine, semen or uterine discharges.[14] Leptospires invade the host through abraded skin or after contact with mucous membranes, such as the conjunctiva. Animals can also become infected by ingesting organisms, by venereal transmission of organisms or through *in utero* exposure to organisms.[8] Urinary excretion of organisms in natural hardjo-bovis infections can persist more than a year.[27] Long-term shedding provides heavy contamination of the environment, which can result in indirect transmission because leptospires have been shown to survive for six months in supersaturated soil conditions and for six days in river water.[34]

For decades, veterinary practitioners in North America have been unable to develop effective control measures against hardjo-bovis infection due to difficulties in diagnosis and lack of effective vaccines. Studies found a commercial pentavalent vaccine failed to prevent infection, renal colonization, stillbirths and weak calves in vaccinated heifers challenged by conjunctival instillation of hardjo-bovis organisms while pregnant.[8] Recently, several manufacturers have introduced vaccines in the US with claims of protection against hardjo-bovis. One of these vaccines reportedly induces a potent humoral and cellular immune response[11,31] capable of preventing colonization of the kidneys and reproductive tract by the organism.[5,6]

Improved diagnosis of hardjo-bovis infection in cattle and new vaccines have awakened interest in control of this reproductive pathogen. The proportion of beef herds infected with hardjo-bovis in the US is unknown. The purpose of this study was to determine the herd prevalence of hardjo-bovis infection and the risk factors associated with herd infection in beef cow/calf operations in the US.

Materials and Methods

Selection of Herds

Six states (California, Florida, Mississippi, Missouri, South Dakota and Texas) were selected to provide a variety of environmental and management conditions characteristic of beef cow/calf operations in the US. Ten beef cattle veterinary practitioners willing to participate in the study were identified per state for Florida, Mississippi, Missouri and South Dakota.

Three of the 10 practitioners in each state were selected to participate in the study through computer generated pseudo-random number assignment to a list of possible cooperators. California and Texas were each divided into three regions, and four veterinary practitioners willing to participate in the study were identified for each region. One veterinarian in each region was randomly selected as above to participate in the study. The three regions sampled in California were north coast, Sierra Nevada foothills and the central valley / south coast. Texas was divided into east Texas, the Gulf Coast and central / west Texas.

Each of the three collaborating practitioners in each state identified 10 beef herds within their practice area willing to participate in the study. Potential study herds were required to consist of 100 or more cows, have adequate facilities to restrain cows for sample collection, to not have vaccinated cattle with multivalent leptospiral vaccines within two months of study commencement and to never have vaccinated cattle with monovalent *L. borgpetersenii* serovar Hardjo vaccine.[a] Four of the 10 herds submitted by each participating practitioner were selected to be sampled through computer-generated, pseudo-random number assignment to a list of the herds. Herds were selected without bias towards a previous diagnosis of leptospirosis, or a history of reproductive problems. A total of 72 herds and 18 veterinary practitioners were selected to participate in the study.

Sampling Methods

In each of the study herds, blood and urine samples were collected from 15 females at least two years of age. It was suggested, but not required, that cows found nonpregnant at pregnancy examination or cows with a history of poor reproductive performance be sampled. Blood was collected into serum-separator vacutainers, cows were administered 500 mg of furosemide intravenously or intramuscularly, and approximately 45 mL of clear urine was collected into sterile plastic conical tubes.[33] A new pair of latex examination gloves was used to sample each cow to protect the urine collector from exposure to leptospirosis and to prevent cross-contamination. Samples were placed on ice or refrigerated, and shipped cold within 24 hours to the Diagnostic Center for Population and Animal Health at Michigan State University for analysis.

Diagnostic Tests

Serum samples were tested for antibodies against leptospiral serovars Grippotyphosa, Hardjo, Icterohaemorrhagiae and Pomona using the microscopic agglutination test.[12] Serum dilutions of 1:25, 1:50, 1:100, 1:200, 1:400 and 1:800 were tested. Titers were recorded as the reciprocal of the highest (final) dilution of serum that agglutinated approximately 50% of leptospires.

The condition (clean or contaminated with fecal material) of urine samples was recorded at arrival to the laboratory. Urine was concentrated by centrifugation, and the sediment was washed with water. A drop of 25 to 30 ul of urine sediment was placed on a glass slide, allowed to dry, and fixed in acetone for 10 minutes. After drying, each spot was stained with a nonserovar specific fluorescein-labeled anti-leptospira antibody conjugate (National Veterinary Services Laboratory, Ames, IA), and counterstained with flazo orange. Leptospires were identified by typical shape and specific flourescence when examined by incident light fluorescent microscopy. A herd was considered to be infected with one of the *Leptospira* serovars if leptospires were detected in one or more urine samples from the herd by the immunofluorescence test.

Indication of Likely Infecting Serovar of Leptospira

Serologic results were evaluated to identify the likely infecting serovar of *Leptospira* when leptospires were detected in urine. Herd infection with hardjo-bovis was inferred if one or more cows had leptospires in their urine, accompanied by either disproportionately high antibody titers to hardjo-bovis (i.e. beyond that expected due to vaccination) or low titers to hardjo-bovis accompanied by low titers against the other serovars of *Leptospira*.

Risk Factors

Data on possible risk factors for herd infection with *Leptospira* were obtained from a questionnaire on herd resources and management completed by the herd's owner, usually with the help of its veterinarian (Table 1). Breeding seasons were classified as spring (April through June), summer (July through September), fall (October through December), or winter (January through March). Breeding seasons that spanned more than one of these periods were recorded as combinations of them. Herds that calved 300 days or more were classified as having an all-year calving season. Average annual rainfall, in inches, at the herd location was recorded by the herd owner. In addition, annual values for average temperature, average high temperature and average low temperature were recorded for the zip codes of each ranch.[b]

Statistical Methods

The modeling of risk factors for positive herds was performed in three stages utilizing a commercially available statistical program.[c] In stage 1, all factors were analyzed, individually, for association using chi-square analysis. For the second stage of modeling, some recoding was done for parsimony. State risk was recoded to code South Dakota as a risk factor with all other states pooled. Breeding season was considered "long" if greater than 110 days. Mean temperature was split into three categories: < 55°F (13°C); 55 to 65°F (13 to 18°C) and > 65°F (18°C). For stage 3, all factors significant at the $P < 0.05$ level were entered into a multivariate model, and a backward stepwise elimination was used until all factors were significant at a $P < 0.1$ level.

Results

Herd Prevalence

Samples were received from 69 of the 72 randomly selected herds. The samples from two herds were discarded due to deterioration, leaving 67 herds with satisfactory samples. Herd size varied from 103 to 7,500 cows. There was a mean of 204 cows (standard deviation [SD] 94) in the 51 herds with less than 500 cows, and a mean of 1,992 cows (SD 2,243) in the 16 herds with over 500 cows. The number of serum/urine sets of samples per herd ranged from 10 to 15, with a mean of 14.4 (SD 1.4).

Twenty-eight (42%) of the 67 herds had one or more animals with leptospires in their urine identified by the flourescein-labeled antibody test accompanied by a se-

Table 1. Variables collected in the herd questionnaire evaluated for possible association with herd infection with *Leptospira* hardjo-bovis.

Location of herd
Predominant breed
Herd size (number of breeding females)
Number of acres of ranch
Average rainfall at herd location (inches per year)
Water source(s) for herd (well, pond, creek, river, etc.)
Start and end of breeding season
Contact with dairy animals in past two years (no, yes - describe)
Herd additions in past two years (no, yes - describe)
History of low pregnancy rates in past two years (no, yes - describe)
History of abortions in past two years (no, yes - describe)
History of calf deaths in last two years (no, yes - describe)
Leptospira vaccination history of animals sampled:
- Date(s) of vaccination in past year
- Product(s) used
- Source of vaccines (veterinarian, distributor, catalog, etc.)
- Has Spirovac ever been administered to any animal in this herd? (no, yes)

Vaccines used for this herd for nursing calves, weaning/stocker, replacement heifers, cows, or bulls:
- Infectious bovine rhinotracheitis virus
- Bovine viral diarrhea virus
- Parainfluenza-3 virus
- Bovine respiratory syncytial virus
- Vibriosis (Campylobacteriosis)
- Clostridial diseases
- *Haemophilus somnus*
- Trichomoniasis
- *Neospora caninum*
- Other cattle diseases (tetanus, anaplasmosis, etc.)

rologic profile compatible with chronic infection with hardjo-bovis. The number of positive animals in each set of samples for infected herds varied from one to five, with a mean of 2.5 (SD 1.2). Within infected herds, a mean of 17% (SD 8%) and range of 7 to 33% of animals sampled had leptospires in their urine.

Herd prevalence of hardjo-bovis infection in the six states ranged from a high of 58% in Mississippi to a low of 8% in South Dakota (Figure 1). In addition to the 28 herds classified positive, five herds classified as negative had serologic profiles characteristic of hardjo-bovis infection (one or more cows with MAT titers 1:800 or greater), but leptospires were not detected in the urine samples submitted. Two of the five herds were located in Mississippi, while Florida, Missouri and Texas each had one herd.

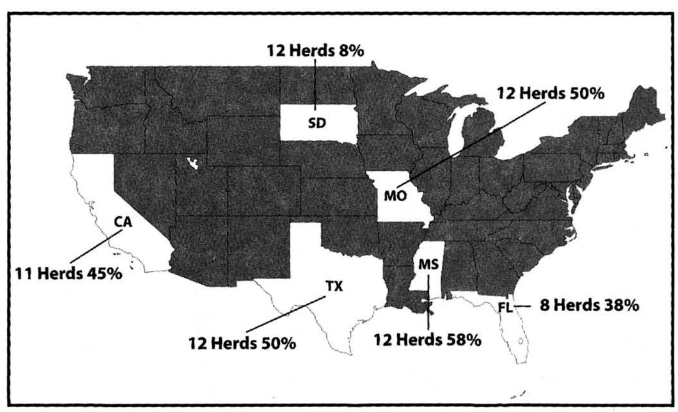

Figure 1. Number of beef herds sampled and herd prevalence of infection with *Leptospira* hardjo-bovis in six states within the United States.

Risk Factors

Geographic location of herd, mean annual temperature and length of breeding season were risk factors for herd infection with hardjo-bovis. Also, herds with ponds as a source of drinking water may be at greater risk than herds without ponds. All other risk factors evaluated were not associated with herd prevalence of hardjo-bovis infection.

The 12 herds located in South Dakota had a prevalence rate for hardjo-bovis of 8%, while the 55 herds in other states had a prevalence rate of 49% (OR 0.10; P=0.01). As the mean annual temperatures in herds increased from 46°F to 63°F (6°C to 17°C), herd prevalence increased from 8% to 71%, but then declined to 31% in herds with mean annual temperatures of 70°F (21°C; Figure 2). Compared to a baseline of the 16 herds with a mean annual temperature of <55°F, the 35 herds with mean annual temperatures of 55 to 65°F had an odds ratio (OR) of 5.15, and the 16 herds with mean annual temperatures greater than 65°F had an OR of 1.97 for infection (P = 0.02). As the length of the breeding season increased from approximately two months to greater than six months, herd prevalence of hardjo-bovis infection increased from 31% to 57% in a linear fashion (Figure 3). The 29 herds with a breeding season of < 95 days had a 24% prevalence of hardjo-bovis infection, compared to a 53% prevalence in the 38 herds with a breeding season > 95 days (OR 3.5; P = 0.02).

The 15 herds that did not have ponds as a source of drinking water had a 27% prevalence of hardjo-bovis infection, while the 52 herds that had ponds as a source of drinking water had a 44% infection rate (OR 2.2; P=0.23). As mean annual rainfall increased, the percentage of herds infected with hardjo-bovis also increased (Figure 4), however, the relationship was not statistically significant (P=0.33).

Discussion

Our findings of hardjo-bovis infection in 42% of US beef herds, combined with Prescott's report[35] that 44% of Ontario beef herds that had not been vaccinated against hardjo-bovis contained seropositive cows, indicate that infection with hardjo-bovis is widespread in North American beef cattle herds. True herd infection rates in the US may be higher than we found because only a subset of animals was tested in each herd, and the sampling strategy was designed to provide 95% confidence of detecting at least one test positive cow if the prevalence of infection in the herd was 20% or greater.

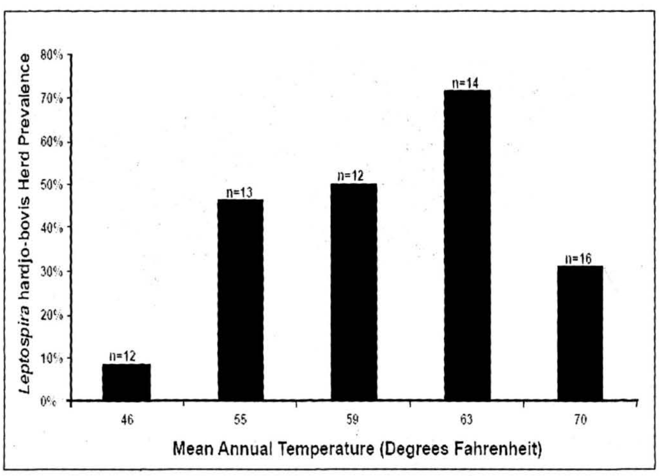

Figure 2. Relationship between mean annual temperature and herd prevalence of infection with *Leptospira* hardjo-bovis (n = number of herds). Compared to herds with a mean annual temperature of < 55°F, herds with mean annual temperatures of 55 to 65°F had an odds ratio (OR) of 5.15 and herds with mean annual temperatures > 65°F had an OR of 1.97 for infection (P = 0.02).

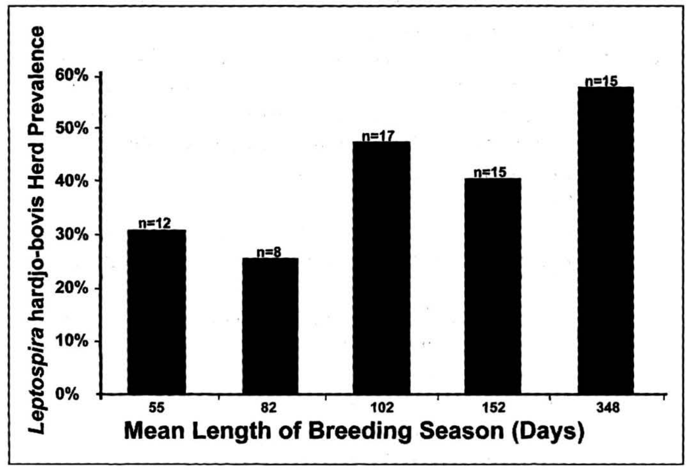

Figure 3. Relationship between mean length of breeding season and herd prevalence of infection with *Leptospira* hardjo-bovis (n = number of herds). Compared to herds with a breeding season < 95 days, herds with a breeding season > 95 days had an OR of 3.5 for infection (P = 0.02).

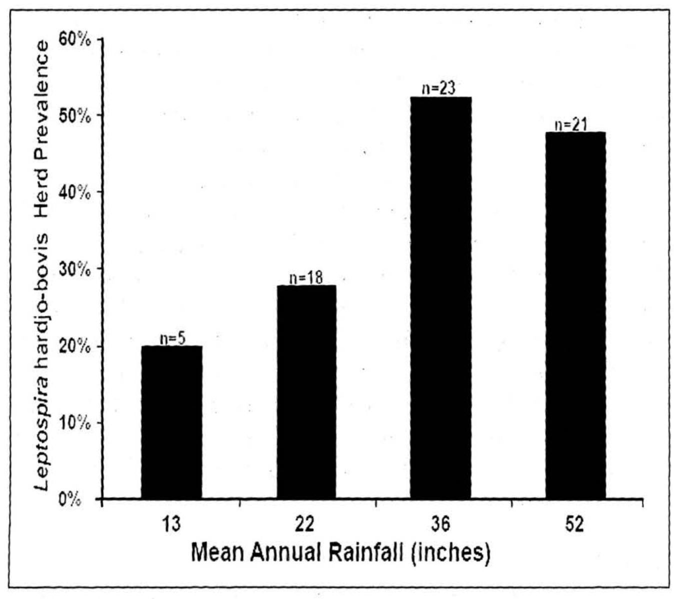

Figure 4. Relationship between mean annual rainfall and herd prevalence of infection with *Leptospira* hardjo-bovis (n = number of herds). The relationship was not statistically significant (P = 0.33).

Herds with fewer infected animals would be less likely to be detected using this strategy. Also, one or more cows in five of the herds classified as negative had high antibody titers to serovar Hardjo, but leptospires were not detected in their urine. Titers of that magnitude are likely responses to acute infection with hardjo-bovis, and those herds may have been falsely classified as negative.

Detection of hardjo-bovis infection of cattle is very difficult even though a diagnosis can be made with many laboratory tests, including isolation of organisms in cultures, serum MAT titers, and identification of organisms in urine or tissues by fluorescent antibody techniques, or polymerase chain reaction (PCR).[2,25,39] The gold standard for diagnosis of leptospirosis is culture of organisms from infected tissues or fluids. Culture allows for identification of specific serovars, however, it is expensive and takes many weeks to complete.[39] In addition, a factor in urine of vaccinated cattle inhibits *in vitro* growth of serovar Hardjo from the urine of vaccinated, but infected cattle, making isolation extremely difficult.[5,8,10]

The standard diagnostic approach for leptospiral infection in cattle, detection of high titers of agglutinating antibody to a specific leptospiral serovar, does not work well to detect hardjo-bovis infections. In contrast to the very high (1:10,000 to 1:100,000) and enduring MAT antibody response that cattle mount when they are infected with leptospiral serovars for which cattle are incidental hosts, such as serovar Pomona, their antibody response to hardjo-bovis infection is much lower and of short duration.[13] Cattle are maintenance hosts for hardjo-bovis, and may have antibody titers that fall below 1:100 within a few weeks after infection or never develop an antibody titer >1:100.[7,14] By the time of abortion, which is usually four to 12 weeks after infection with hardjo-bovis, antibody titers may be very low or absent.[5,10,16,39] Sensitivity of the MAT test for detecting hardjo-bovis infection is poor, with a sensitivity of 67% at a titer cut-off of 1:10 and 41% sensitivity at a titer cut-off of 1:100.[16] Therefore, serologic examination alone often fails to detect cattle infected with hardjo-bovis.

Leptospires appear in the urine of cattle infected with hardjo-bovis within 14 to 21 days of infection, and continue to be shed for a mean of eight months and as long as 18 months or even years.[27,44] In contrast, leptospires are found in the urine of cattle infected with other common serovars of *Leptospira* for a comparatively short period of time, and such shedding is accompanied by high titers of antibody easily detected by serology. The long-lasting urinary shedding of hardjo-bovis infection, and the direct methods to detect the organisms in urine, makes screening of urine samples a useful diagnostic approach to detect infection with this organism.[9]

Flourescent antibody testing or PCR testing of urine, however, is not serovar-specific.[18,46,47] In this study, demonstration of leptospiral organisms in the urine by fluorescent antibody testing was combined with evaluation of antibody titers to several serovars of *Leptospira* to indicate if the observed organism was likely to be hardjo-bovis. Others have used this combination of tests to diagnose infection with hardjo-bovis.[28]

The very low herd prevalence found in South Dakota, compared to high herd prevalences in states located in the middle or southern portion of the US, agreed with Miller, who found a lower seroprevalence to *Leptospira* in cattle in the northern portion of the nation.[30] That is likely a result of the low mean temperatures in northern states and the relatively low cattle density in those herds. Leptospiral organisms thrive in warm environments.[17] Our finding of a higher herd prevalence as mean annual temperatures rose is in agreement with that and Miller, who reported a higher rate of isolation of leptospiral organisms from kidneys of cattle processed in slaughter plants located in regions with higher mean temperatures.[30] It was a surprise, however, to discover a 40% decline in prevalence in the 16 herds with a mean annual temperature of 70°F (21°C), compared to the 14 herds with a mean annual temperature of 63°F (17°C). This probably confirms that although leptospiral organisms thrive in moist, warm environments, they do not do well in extremely hot climates. Ambient temperatures higher than 93 to 96°F (34 to 36°C) are detrimental to their survival.[36]

Increased herd prevalence as the length of breeding season increased may be related to a seasonal pattern of transmission of hardjo-bovis infection. Long breeding seasons would increase the chance that some breeding or calving takes place during the season of highest transmission. Miller found that seroprevalence for *Leptospira* was significantly lower in the spring than summer, fall or winter.[30] Also, a seasonal pattern of abortions due to infection by hardjo-bovis was observed in Ontario.[35] Over a two- year period, 65% of fetuses diagnosed as abortions due to infection with hardjo-bovis were submitted to the diagnostic laboratory during November through January. In the present study, herds with a spring breeding season had a lower hardjo-bovis prevalence (29%) than herds with a fall breeding season (40%) or an all-year breeding season (57%), but this relationship was not statistically significant. Our data suggest that shortening the breeding season to 90 days or less is a management practice that could reduce the likelihood of a herd being infected with hardjo-bovis.

Leptospiral infections of man and animals are commonly thought to be associated with wet environments. This study revealed some interesting relationships between herd prevalence of hardjo-bovis infection and water. Although there was a trend for higher herd prevalence in higher rainfall areas, that relationship was not statistically significant. That agrees with Miller who reported no association between isolation of leptospiral organisms from the kidney and mean annual precipitation.[30] Some herds diagnosed as positive in this report were large, extensively managed herds in a dry climate, even though direct sunlight and desiccation are rapidly detrimental to leptospires. The finding of high herd prevalence for hardjo-bovis in environments not typically associated with leptospirosis counters the dogma that leptospiral infections occur primarily in wet environments. The extremely efficient means of hardjo-bovis transmission by long-term shedding of organisms in the urine of chronic carriers and spread from cow-to-cow by direct contact is likely responsible for its presence in low rainfall regions. A veterinarian who practices in a low rainfall area, however, feels that the high herd prevalence of hardjo-bovis infection in his clients' beef herds is associated with ponds as a water source.[21] That may be true because the ability of leptospiral organisms to survive for long periods of time in ponds offers a second highly efficient means of transmission. The association between ponds as a source of drinking water and the likelihood of a herd being infected with hardjo-bovis, although not statistically significant in this study, warrants further investigation.

Conclusions

Infection with hardjo-bovis is widespread in beef herds of North America. It is difficult to diagnose in individual animals with laboratory tests presently available, however, diagnosticians are working to develop tests that are more sensitive and serovar-specific. Altering risk factors that predispose herds to infection, such as shortening length of breeding season, should increase the effectiveness of hardjo-bovis control programs when added to modern vaccination and biosecurity practices.

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Endnotes

[a] Spirovac, CSL Ltd, Parkville, Victoria, Australia
[b] National Oceanic and Atmospheric Administration, National Weather Service, Silver Spring, MD
[c] MINITAB statistical software, Minitab Inc, State College, PA

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Abstract

Production and Metabolic Response to the Addition of Live Yeast or Yeast Culture or No Yeast to Lactating Cows[a]

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Cows in early lactation (n=131) were fed a switch-back TMR containing corn silage, alfalfa hay, and a grain mix containing ground corn, soybean meal, whole cottonseed, bypass protein, vitamins and minerals. Fresh cows (n=216) were added to the group after calving. Cows were on a switch-back trial as follows: no yeast (NY) three weeks, yeast culture (DV) three weeks, no yeast three weeks, live yeast (WY) three weeks then repeated. Daily milk weights were captured electronically. Milk yield responses of the treated (yeast) and control (no yeast) groups did not differ statistically. There was a significant increase of abomasal displacements ($P<0.01$) in the NY group. Yeast feeding may be a factor in rumen and abomasal health in the early lactating cow.

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