Estimated Production and Economic Losses from *Neospora caninum* Infection in Texas Beef Herds

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Abstract

A computerized spreadsheet was used to model economic losses attributed to changes in production parameters for a typical 42 head Texas beef herd following a simulated *Neospora caninum* infection. Texas beef herds that completed Standardized Performance Analysis (SPA) records between 1991-1997 supplied the representative production information for economic analysis. SPA production parameters that were used included pregnancy percentage, calving percentage (live calves born), calf death loss between birth and weaning (%), weaned calf crop (%), pounds of calf weaned per female exposed to bulls at start of breeding season, and replacement percentage. The prevalence of *N. caninum* across and within herds, the risk of increased abortions and stillbirths in infected cows, and the percentage of aborting cows that were culled were collectively superimposed onto the production information in the model either as static estimates (deterministic model) or changing estimates (stochastic model) to cause change in production parameters.

Using a deterministic approach and compared to a non-infected herd, a herd with a 20% prevalence of infection experienced an estimated 2.4% lower calving percentage and an overall estimated 2.3% lower weaned calf crop. Estimated weaned calf weight per exposed female was 12.3 lb (5.6 kg) less in an infected herd. Predicted economic loss was $13.75 per head ($577.50 herd loss). Using software that facilitated stochastic modeling, average predicted loss was between $23.29 per head ($978.18 herd loss) and $35.21 per head ($1478.82 herd loss). The total predicted economic loss to the Texas beef industry from this disease was estimated to be $7.6 million using the deterministic economic model. When prevalence figures were allowed to vary, the most likely financial losses to the Texas beef industry were predicted to be between $15 million and $24 million.

Introduction

Reports of *Neospora caninum* as a cause of reproductive failure in cattle first appeared in the late 1980's.[2] Exposure to this coccidian parasite is widespread in U.S. dairy and beef cattle. According to National Animal Health Monitoring System (NAHMS) data, approximately 10% and 11% of dairy cows and beef cows, respectively, tested positive to *N. caninum* antibody.[2] The NAHMS data further indicated that at least one animal tested positive in 75% of the dairy herds and 60% of the beef herds. In Texas, seroprevalence of *N. caninum* in beef cattle herds appears similar to NAHMS figures.[1]

The production losses and economic consequences of this disease in U.S. livestock have been characterized best in dairy cattle.[2,8,9,13,14] Although a *Neospora* seropositive cow is still able to become pregnant, a persistent asymptomatic infection occurs.[9,13] Many infected cows may abort in the face of initial infection and in subsequent pregnancies.[8,13] Reduced milk production and premature culling are also observed consequences of *N. caninum* infection in these cows.[14] Rarely, calves born to infected dairy cows may have neurologic signs, hind and/or forelimb flexural/extensor abnormalities, may be underweight, or unable to rise.[2]

Economic losses have been estimated for the California dairy industry.[2] Abortion is estimated to cost the producer $500-900/hd. Considering additional monetary losses from milk production and premature culling, the overall financial loss is approximately $35 million annually.[2]

In beef cattle, less is known about the production losses attributed to *N. caninum* infection at the herd level. Recently, clinicians reported the results of a 4-year study of *N. caninum* infection in 419 cows monitored from 8 beef herds (total = 1239 cows) in central Alberta.[16] Results indicated that similar to dairy cows,[9,13] infection did not prevent a cow from conceiving, but seropositive cows were at increased risk of abortion.[16] However, unlike dairy cattle, an increase in calf mortality at birth was observed in seropositive cows compared to seronegative contemporaries.[16] Analyses of the economic impact of *N. caninum* in North American beef herds have not been published. The following report summarizes a computer modeling analysis of the predicted production and economic losses that result following a simulated introduction of *N. caninum* infection in Texas beef herds.

Materials and Methods

Herd model. The average herd size in Texas in 1998 was 42 beef cows (5.52 million beef cows in 133,000 herds).[12] However, only 49% of the cows are represented when 91.9% (121,500) of the herds (average herd size = 22 head) are considered.[12] The remaining 51% of cow inventory is in 11,500 herds (average herd size = 245 head).[12] Consequently, an initial simulation was performed comparing the production and financial data for a small (22 hd) and a large (245 hd) beef cattle herd following the simulated introduction of a *N. caninum* infection.

Production information that was used to model financial changes was obtained from a database of 196 Texas beef herds that had voluntarily completed a Standardized Performance Analysis (SPA) record between 1991-1997.[7] Beef herds owning 1-49 females (N=24 herds) and 200-299 females (N=27 herds) were extracted from this data base to supply representative production information for each herd simulation. Compared to a large herd, a small herd had higher baseline SPA values for pregnancy percentage (93% vs 90%), calving percentage (88.95% vs 87.32%), calf death loss at birth (2.4% vs 1.0%), and weaned calf crop (86.6% vs 84.7%) but a slightly lower value for calf death loss between birth to weaning (2.6% vs 3.0%) and markedly lower pounds of calf weaned per exposed female (417.5 lb vs 462.2 lb). In utero losses (2.0%) were the same for these herds.

Production and economic model. A computerized spreadsheet[a] was used to model economic losses attributed to changes in production parameters for a single small and a single large Texas beef herd following a simulated *N. caninum* infection. Parameters associated with *N. caninum* infection that were used in the model included prevalence of *N. caninum* across and within herds, risk of increased abortions and stillbirths in infected cows, and percentage of aborting cows that are culled. These parameters were collectively superimposed into the model either as static estimates (deterministic model) or changing estimates (stochastic model) to record the change in production parameters. SPA production parameters that were used included pregnancy percentage, calving percentage (live calves born), calf death loss between birth and weaning (%), weaned calf crop (%), pounds of calf weaned per female exposed to bulls at the start of the breeding season, and replacement percentage.[7]

In the deterministic model, in each simulated herd the *N. caninum* infection prevalence in cows was set at 20% along with a 5.7 fold increased relative risk of abortion (2.0% abortion in non-infected cows; 11.4% abortion in infected cows) and a 2.8 fold increased relative risk of delivering a stillborn calf (2.8% stillborns for non-infected cows; 7.8% stillborns for infected cows) among the infected cows. Fifty percent of the infected cows that aborted were arbitrarily culled. The 20% infection prevalence mimicked that observed within Texas beef herds.[1] Relative risk figures for abortion and delivery of a stillborn calf were obtained from epidemiologic information from a previous study of *N. caninum* infection in Canadian beef cattle.[16] The arbitrary 50% cull rate for aborting cows was in contrast to a normal 15% replacement rate (culls for reproductive failure, lameness, age, etc.) in SPA herds.[7]

The prevalence and relative risk figures cause change in the key measure of production, pounds of calf weaned per exposed female. Using current market prices, financial loss on a per exposed cow basis ($/hd) was calculated as the sum of the difference in revenue ($/hd) generated from the pounds of calf weaned per exposed female for infected cows versus non-infected cows, plus the difference in cost ($/hd) of replacing the number of cows culled in an infected versus non-infected herd. Market prices used included a $80/cwt calf market, $700/hd replacement cost, and $300/hd cull cow revenue. Obviously, the amount of economic loss will fluctuate in response to changing market conditions.

Using the economic loss ($/hd) information generated for each simulated herd, an estimate of the total state loss ($) to this disease was made based upon a static estimate that 50 % of the herds in each size category were seropositive to *N. caninum* and that within herd prevalence of this disease was 20%. The across and within herd prevalence figure mimicked that observed in Texas beef cow-calf operations.[1]

Additional software[b] was used to convert the static assumptions used in the described deterministic model into a dynamic model providing uncertainty in outcome (stochastic model). Contained within the software, two different functions (pert and triangular) were used that generate probability distributions for inputs of a minimum, most likely, and maximum value for a given parameter. A minimum, most likely, and maximum probability of 0%, 20%, and 80%,[1] respectively, was used for within-herd prevalence of *N. caninum* for each simulated herd. The minimum, most likely, and maximum relative risk used for abortions was 1.7, 5.7, and 18.5,[16] respectively, for each simulated herd. The minimum, most likely, and maximum relative risk for stillbirths was 1.1, 2.8, and 7.1,[16] respectively, for each simulated herd. The minimum, most likely, and maximum culling rate was set at 0%, 50%, 100%, respectively, for each simulated herd. One hundred simulation runs (1000 iterations/run) were conducted for the pert and triangular functions. The output from all iterations generated separate probability distributions for financial loss to a herd ($/hd).

Using the same pert and triangular functions in simulation, financial loss figures ($/hd) for the herd were, in turn, combined with a range of across and within-herd prevalence percentage figures to estimate the total economic loss ($) to the Texas beef industry from *Neospora caninum*. A minimum, most likely, and maximum probability figure of 0%, 50%, and 60%, respectively,[1] was selected for across herd prevalence and a minimum, most likely, and maximum probability of 1%, 20%, and 80%, respectively[1] was used for within-herd prevalence. One hundred simulation runs (1000 iterations/run) were conducted to generate the probability distribution curve for financial loss ($).

Results

Although most SPA measures of production efficiency favored the small herd, the markedly higher baseline value for pounds of calf weaned per exposed female for a large herd negated emergence of any distinct financial differences between herds when *N. caninum* epidemiologic parameters were superimposed on production data. Financial losses varied less than one dollar per head ($13.32/hd vs $12.41/hd for small and large herd, respectively) in the deterministic simulation. Using stochastic modeling and the probability distribution generated by the more conservative pert function, small herds experienced a $1.36/hd ($22.59/hd vs $21.23/hd for small and large herd, respectively) higher loss. The probability distribution generated by the triangular function produced a $1.85/hd difference in loss ($34.21/hd vs $32.36/hd for small and large herd, respectively).

Since herd size accounted for only a narrow disparity in financial losses realized, a simulation based on a single herd size (42 hd) representative of all 133,000 beef enterprises in Texas[7] was developed. SPA production information was adjusted for differences in herd size. This revised simulation is the subject of the following production and financial results (Table 1 and 2).

Using a deterministic approach and compared to a non-infected herd, a herd with a set 20% prevalence of infection experienced an estimated 2.4% lower calving percentage and overall 2.3% lower weaned calf crop (Table 1). An infected herd produced an estimated 12.3 lb (5.6 kg) less weaned calf weight per exposed female. The reduced calf weight represented a 2.9% reduction in productivity to a ranch. Estimated economic loss was $13.75 per head. The loss was attributed to a combined $9.80/hd reduction in gross revenue from calf weight weaned per exposed female and $3.95/hd in added expense for replacement costs. Overall, predicted annual economic loss to a typical 42 head Texas beef herd was $577.50.

Using a stochastic approach and the more conservative probability distribution generated by a pert function, the estimated mean within herd prevalence of disease was 26.7% (Table 2). The estimated mean abortion loss (%) and calf loss at birth (%) for infected cows was 14.3% and 9.1%, respectively. In an infected herd, calving percentage was expected to be 4.0% lower and weaned calf crop was expected to be 3.9% lower. An infected herd produced an estimated 20.9 lb (9.5 kg) less weaned calf weight per exposed female. The reduced calf weight represented a 4.9% reduction in productivity to a ranch.

The predicted distribution of financial losses to these beef enterprises from endemic or epidemic infection ranged between nearly nothing ($0.24/hd) to $106.47/hd, but 95% of the herds experienced losses not exceeding $48.05/hd. Predicted mean loss was $23.29/hd due to a combined $16.66/hd reduction in gross revenue from calf weight weaned per exposed female and $6.63/hd in added expense for replacement costs (Table 2). Overall, the predicted total economic loss to a typical 42 head Texas beef herd was $978.18.

A triangular probability distribution predicted a higher mean loss of $35.21/hd with a range of $0.66/hd to $129.08/hd. Ninety five percent of ranches would probably experience losses not exceeding $71.29/hd. The predicted mean loss of $35.21/hd was attributed to a combined $25.23/hd reduction in gross revenue from calf weight weaned per exposed female and $9.98/hd in added expense for replacement costs. Overall, predicted economic loss to a typical 42 head Texas beef herd was $1478.91. These financial figures reflected the higher estimate of the triangular probability distribution for within herd prevalence of disease (33.3%), abortion loss (17.3%) and calf loss at birth (10.3%) for infected cows. In an infected herd, calving percentage was expected to be 6.1% lower and weaned calf crop was expected to be 5.9% lower. This translated into an estimated 31.6 lb (14.4 kg) less weaned calf weight per exposed female.

Table 1. Deterministic simulation model of production and economic response of a Texas beef herd to infection with *Neospora caninum*

	Non-infected herd	Infected herd
Breeding females (hd)	42	42
Neospora prevalence (%)	0.00	20.0
Production information*		
Pregnancy %		
Non-infected cows	86.7	86.7
Infected cows	0.0	86.7
Pregnant females (hd)		
Non-infected cows	36	29
Infected cows	0	7
In Utero losses (%)		
Non-infected cows	2.0	2.0
Infected cows **	0.0	11.4
Calves (live and dead) born (hd)		
Non-infected cows	36	29
Infected cows	0	6
Calf death loss at birth (%)		
Non-infected cows	2.8	2.8
Infected cows †	0.0	7.8
Live calves at birth (hd)		
Non-infected cows	35	28
Infected cows	0	6
Calving percent (live birth) (%)	82.6	80.2
Calf death loss birth to weaning (%)		
Non-infected cows	3.3	3.3
Infected cows	0.0	3.3
Weaned calf crop (hd)		
Non-infected cows	34	27
Infected cows	0	6
Weaned calf crop (%)	79.9	77.6
Weaning weight (lb)		
Non-infected cows	537.0	537.0
Infected cows	0.0	537.0
Calf weight produced per exposed female (lb)	428.9	416.6
Culls		
Non-infected cows – normal replacement (%)	15	15
Infected cows that abort – replacement (%)	0	50
Total culls (hd)	6	7
Financial information		
Revenue from calf sales		
Weaned calf pay weight ($/cwt)	80.00	80.00
Calf gross revenue per exposed female ($/hd)	343.09	333.29
Difference in gross revenue per exposed female ($/hd)		(9.80)
Cost of replacements ($/hd)		
Replacement cost	700.00	700.00
Salvage value	300.00	300.00
Net cost of replacement	400.00	400.00
Replacement cost per exposed female ‡	60.00	63.95
Difference in replacement cost per exposed female		3.95
Total economic losses ($/hd)		**13.75**
Total economic losses for herd ($)		**577.50**

* Production information obtained from Standardized Production Analysis (SPA) records of 196 Texas beef herds (1991-1997)
** 2.0 % normal in utero loss X 5.7 relative risk
† 2.8 % normal calf loss at birth X 2.8 relative risk
‡ (No. cull cows / No. breeding females) X net replacement cost

Table 2. Stochastic simulation model of production and economic response of a Texas beef herd to infection with *Neospora caninum*

	Non-infected herd	Infected herd
Breeding females (hd)	42	42
Neospora prevalence (%) *	0.00	26.7
production information		
Pregnancy %		
Non-infected cows	86.7	86.7
Infected cows	0.0	86.7
Pregnant females (hd)		
Non-infected cows	36	27
Infected cows	0	10
Pregnancy losses (%)		
Non-infected cows	2.0	2.0
Infected cows **	0.0	14.3
Calves (live and dead) born (hd)		
Non-infected cows	36	26
Infected cows	0	8
Calf death loss at birth (%)		
Non-infected cows	2.8	2.8
Infected cows †	0.0	9.1
Live calves at birth (hd)		
Non-infected cows	35	25
Infected cows	0	8
Calving percent (live birth) (%)	82.6	78.6
Calf death loss birth to weaning (%)		
Non-infected cows	3.3	3.3
Infected cows	0.0	3.3
Weaned calf crop (hd)		
Non-infected cows	34	25
Infected cows	0	7
Weaned calf crop (%)	79.9	76.0
Weaning weight (lb)		
Non-infected cows	537.0	537.0
Infected cows	0.0	537.0
Calf weight produced per exposed female (lb)	428.9	408.0
Culls		
Non-infected cows – normal replacement (%)	15	15
Infected cows that abort – replacement (%)	0	50
Total culls (hd)	6	7
Financial information		
Revenue from calf sales		
Weaned calf pay weight ($/cwt)	80.00	80.00
Calf gross revenue per exposed female ($/hd)	343.09	326.43
Difference in gross revenue per exposed female ($/hd)		(16.66)
Cost of replacements ($/hd)		
Replacement cost	700.00	700.00
Salvage value	300.00	300.00
Net cost of replacement	400.00	400.00
Replacement cost per exposed female ‡	60.00	66.63
Difference in replacement cost per exposed female		6.63
Total economic losses ($/hd)		**23.29**
Total economic losses for herd ($)		**978.18**

* Determined by @Risk™ software from input of minimum, most likely, and maximum prevalence of 0%, 20%, and 80%, respectively (pert probability distribution)

** 2.0 % normal in utero loss X 7.15 relative risk (determined by @Risk™ software from input of minimum, most likely, and maximum relative risk of 1.7, 5.7, and 18.5, respectively; pert probability distribution)

† 2.8 % normal calf loss at birth X 3.25 relative risk (determined by @Risk™ software from input of minimum, most likely, and maximum risk of 1.1, 2.8, and 7.1, respectively; pert probability distribution)

‡ (No. cull cows / No. breeding females) X net replacement cost

In summary, these two probability distributions predicted that mean losses would be between $23.29/hd and $35.23/hd, and that approximately 95% of beef enterprises would experience losses not exceeding $53.08/hd to $71.29/hd.

The total economic loss to the Texas beef industry from this disease was predicted to be $7.6 million using the deterministic economic model. This figure was based upon a $13.75/hd loss allocated to a static 50% across herd prevalence (66,500 infected herds) and 20% within-herd prevalence of disease (552,000 infected cows). When prevalence figures were allowed to vary, the more conservative beta pert probability distribution predicted a range of losses to the Texas beef industry from $206.4 thousand to $96.6 million. Predicted mean economic loss was $15 million and 95% of the losses sustained in simulation did not exceed $38.7 million. The $15 million mean loss was based upon a $23.29/hd loss allocated to an across herd prevalence of 43.3% (57,633 infected herds) and 26.8% within-herd prevalence (641,853 infected cows) of disease.

The triangular probability distribution exhibited a higher predicted mean loss of $24 million with a range of losses between $249.0 thousand and $167.7 million. Ninety five percent of the losses sustained in simulation did not exceed $58.7 million. The mean loss of $24 million was based upon a $35.21/hd loss at the herd level allocated to an across herd prevalence of 36.7% (48,771 infected herds) and 33.7% within-herd prevalence (689,690 infected cows) of disease. In summary, these two probability distributions predicted that losses to the Texas beef industry were most likely between $15 and 24 million.

Discussion

Neospora caninum infection in beef cattle should (and probably will) become a concern to Texas given beef production is such an important source of agriculture-based revenue to the state and the magnitude of monetary losses (as high as $15-24 million annually) predicted by the analysis reported here. The economic impact of this disease in many individual Texas herds is probably under appreciated, except in instances when an abortion "storm" may occur. The predicted loss in cow productivity to a typical Texas ranch from *N. caninum* infection was 2.9% ($13.75/hd) using the deterministic model and 4.9% ($23.29/hd) using stochastic modeling. Total economic losses for a herd was $577.50 and $978.18 depending upon the computer modeling technique used. If a rancher is unaware of this loss (unrealized economic gain) it could be a reflection of small herd size, variable infection rate of cows within herds, or lack of signs of clinical illness in infected cows. In some herds, management practices of continuous breeding, lack of pregnancy testing, or lack of close observation of calving cows can also hinder recognition of increased reproductive failure.

Each rancher must decide whether the 2.9% to 4.9% loss in cow productivity from *N. caninum* infection is worth their investment in time, effort, and money to implement control procedures to recapture this loss. However, it may be premature for a rancher to fret solely about what to do about financial losses associated with *N. caninum* infection if their management style does not include, for example, use of technologies such as cross-breeding, growth promotant implants, or anthelmintic treatment in the cow herd. Hybrid vigor obtained from cross-breeding has been demonstrated to easily improve weaning weight of calves by 5%[5] and implanting[4,15] and de-worming[3] usually increase average daily weight gains by approximately 10% or more. If the above described rancher with poorer management skills wants to improve cow productivity, integrating the aforementioned management practices into their beef enterprise is likely to yield positive economic results much easier and faster than tackling the more difficult job of controlling neosporosis. Good management skills will be required of those attempting to control *N. caninum* infection in their cow herd.

Although *N. caninum* is a cause of considerable economic loss to the Texas beef industry, it is inappropriate to use the information presented here to predict what the economic loss from this disease is in other states, regions, or on a national basis. Production data and epidemiologic information about N. caninum that is unique to each state must be assembled prior to attempting to make a rational estimate of state by state economic losses to this disease.

One of the keys to estimating a rational financial loss figure to *N. caninum* infection for the Texas beef industry hinged on using an accurate figure for calf production in the average beef herd in this state. The pounds of calf weaned per exposed female figure was factual for herds completing a SPA record and, thus, was considered a reasonable estimate of calf production for the other beef enterprises in the state. However, since these ranches were not randomly selected but instead voluntarily completed a SPA record, a selection bias could exist whereby their production information did not reflect that of the average Texas beef herd.

The economic analysis reported here was also subject to distortion depending on the reliability of the parameter estimates for epidemiologic aspects of *N. caninum* infection used in the model. Across and within-herd prevalence of *N. caninum*, abortion rate (%) of infected versus non-infected cows, mortality at birth (%) of calves from infected versus non-infected cows, and death loss between birth and weaning (%) of calves from infected versus non-infected cows were considered to be important epidemiologic factors to use in this economic analysis.

Prevalence figures that were used in this analysis for across and within herd infection of *N. caninum* in Texas was based on a limited amount of in-state serologic information.[1] However, the presence of this coccidian parasite in Texas appears similar to prevalence figures reported previously for dairy cattle and beef cattle in other areas of North America.[9,16] Because of a lack of specific data for Texas beef herds, Canadian[16] information about the relative risk for abortion and calf loss at birth in infected cows was used in the economic analysis reported here. The figures reported for the relative risk of abortion in infected Canadian beef cattle[16] appear similar to those reported for dairy cows in the U.S.[13] The assumption was made that Texas cattle would probably react similarly. The same mortality figures (%) for calves during the period between birth and weaning were used for infected and non-infected cows since available epidemiologic information[2,8,16] suggests infection does not kill calves during this stage of their life.

One additional assumption was necessary to compare in-utero losses between a non-infected and infected herd. The percentage of in-utero losses and losses at birth (stillbirths and dystocia) are combined as one value in SPA herds and are actually determined indirectly by calculating the difference between pregnancy percentage and calving percentage (live calves born). It was assumed that the average Texas beef herd experienced a 2% abortion rate. This abortion rate was similar to what is normally encountered in U.S. beef cattle.[10,11]

A relative risk factor for calf loss at birth was included in this economic analysis with some hesitation. Canadian information appears contrary to data reported for U.S. dairy cows since, to date, no difference has been reported in calf mortality at birth between infected and non-infected dairy cows.[8] However, eliminating this parameter from the economic analysis (deterministic model) reduced losses at the herd level by $3.21/hd to $10.54/hd. Using stochastic modeling, the economic loss was changed from $23.29/hd to $18.14/hd (pert probability distribution) and from $35.21/hd to $27.80/hd (triangular probability distribution).

The number of open cows that a rancher culls on an annual basis is a personal decision. Obviously, the number could vary between all and none. In this analysis, it was assumed that the producer would cull 50% of the infected cows that aborted. Given a normal 15% replacement rate for Texas beef herds,[7] this represented a 3.3 fold increase in the percentage of cows that were culled because of abortion to *N. caninum*. The rationale for placing increased culling pressure on infected cows that abort is the tendency for these persistently infected animals to abort in subsequent pregnancies as well as their increased likelihood to exit a herd prematurely due to other causes.[13,16] However, if the same 15% replacement rate was used for infected and non-infected cows in the deterministic economic analysis, economic loss was reduced by only $2.77/hd. Using the stochastic model, herd loss was reduced by $4.64/hd (pert probability distribution) and $6.98/hd (triangular probability distribution).

Other economic parameters that were considered for inclusion in the economic analysis reported here were (1) reduced daily weight gain of calves through weaning because of lowered daily milk production of an infected dam and (2) added animal health costs associated with diagnostic work-up for reproductive failure in infected herds.

In dairy cows infected with *N. caninum*, a 4-5% reduction in milk production over a lactation period has been reported.[14] In beef cattle, limited information has indicated that calf weight gains of 0.03-0.07 lb (0.014-0.032 kg) are observed for each 1 lb (0.45 kg) change in total 205-day milk yield of their dam.[6] Assuming that beef cows infected with *N. caninum* experience a loss in milk production similar to dairy cows, average daily gain and, thus, body weight at weaning of their suckling calves should be less than those of non-infected contemporaries. However, superimposing this parameter into the production portion of the herd simulation reported here resulted in only a 0.5 lb (0.23 kg) decrease in calf weight weaned per exposed female for an infected herd compared to cows from an uninfected herd. This small difference in weaning weight was considered to be undetectable in most beef enterprises and was removed from the simulation.

It was thought that few requests would probably be made to veterinarians by herd owners wanting to determine a cause for a rise in reproductive failure of their herds. Variable infection rate of cows within herds, lack of clinical signs of illness in infected cows and under-utilization of pregnancy testing were thought to be major contributors to this attitude. Consequently, a cost for veterinary services was not included in the simulation model. Obviously, the estimated economic loss figures for individual herds and the Texas beef industry would be higher if either of these aforementioned economic parameters was included in the analysis.

Conclusions

Predicted economic losses to the Texas beef industry from *N. caninum* infection are sizable based on our computer model using available epidemiologic information for beef cattle applied to actual production data of 196 Texas beef herds. Ultimately, the authors hope that others will be inspired to conduct the appropriate field studies to validate the economic information presented here as well as generate new economic data about this disease in other regions of the U.S.

Footnotes

[a] Excel 97, Microsoft Corporation, Redmond, WA
[b] @Risk version 3.5d, Palisade Corporation, Newfield, NY

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