PEER REVIEWED

A Survey Description of Down-Cows and Cows With Progressive or Non-progressive Neurological Signs Compatible With a TSE From Veterinary-Client Herds in 38 States

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Abstract

The surveillance efforts to detect a potential transmissible spongiform encephalopathy (TSE) disease in U.S. cattle have been in place since 1990. This monitoring program is vital to U.S. interests. Without it, the U.S. would be unable to assure the American public or foreign governments of our freedom from TSEs in the U.S. cattle population. To assess the possibility of a TSE in U.S. cattle, we need estimates of cattle at risk.

The objective of this study was to collect data from practicing veterinarians that would describe non-ambulatory or "downer-cows" in the U.S. cattle population. A second objective was to estimate rates for progressive central nervous system (CNS) conditions potentially compatible with a TSE and determine if affected by regional and herd-size differences. The design of this study was to survey veterinary members of the American Association of Bovine Practitioners (AABP) and compile the data from down cows as reported from their clients' dairy and beef herds.

For non-ambulatory dairy cows with non-progressive neurological signs (NANP), 85% of cases fell into three cause categories: injury/trauma, septicemia/toxemia or non-responsive milk fevers. For beef cows, injury/trauma, septicemia/toxemia and other known CNS disorders cases accounted for the majority (76%) of NANP cows. The profile of the progressive CNS cases in dairy cattle found that other known CNS conditions, septicemia/toxemia, unknown CNS conditions and non-responsive milk fever to be the most frequently reported causes. In beef cattle four case categories accounted for 83.4% of the total reported causes: injury/trauma, known infectious agent, septicemia/toxemia and known CNS conditions.

There were regional and herd-size effects on the percentages and rates for unknown cases and non-recovered, progressive CNS rates. Non-recovery rates for progressive cases were >400/10^6 in the south central and northeast regions. Dairy cattle in the southeast had the highest incidence of progressive and unknown CNS disorders. The same was found for beef cows in the southeast. Results of the herd-size analysis showed that dairy herds with <50 cows and beef herds with <100 cows were at the highest risk for unknown non-progressive plus unknown and total progressive cases in this study. Suggested minimum numbers of tests for surveillance were constructed to account for regional and herd-size differences.

Introduction

Bovine Spongiform Encephalopathy (BSE) has had devastating effects on the cattle industry in Great Britain and other European countries. Beef consumption and prices have dropped in countries and live cattle plus cattle product exports have been banned from them. Meanwhile, evidence for potential transmission of this disease from cattle to humans continues to accumulate.

Here in the United States, USDA/APHIS and the FDA have carried out several actions designed to reduce the risk to the U.S. cattle industry from a transmissible spongiform encephalopathy (TSE), such as BSE. Besides safeguards, such as the ruminant-feed ban and preventing the import of cattle products from BSE countries, USDA/APHIS has been actively monitoring cattle in the United States for the existence of a TSE since 1990. This surveillance system was designed to detect a presence of TSE in the U.S. cattle population. More than 7749 samples from non-ambulatory and neurologic cows >20 months of age have been tested by trained pathologists without a single positive case to date. These samples included field cases of cattle with signs of neurological disease, cattle condemned at slaughter for neurologic reasons, rabies-negative cattle submitted to public health laboratories, neurologic cases submitted to veterinary diagnostic laboratories and teaching hospitals and cattle that were non-ambulatory at slaughter. At this time, USDA/APHIS is analyzing between 700 and 800 samples from neurologic cases and another 300 to 400 samples from non-ambulatory cases at slaughter each year. This surveillance effort is vital to U.S. interests. Without it, the U.S. and our cattle industry would be unable to assure the American public or foreign governments of our freedom from TSEs in the U.S. cattle population.

To make surveillance for TSE in U.S. cattle most effective, it should be targeted toward high risk animals. The challenge is to define and identify which animals are in that high risk population. To assess the possibility that a TSE is present or absent in U.S. cattle, we need estimates of which cattle are at risk. Table 1 shows estimated adult cow numbers taken from the 1998 USDA/NASS data, USDA/APHIS/VS NAHMS Dairy '96 and NAHMS Beef '97 studies. Although the NAHMS data were from cattle population subsets, they were more current and considered reasonable estimates. These data have been used to describe the cattle population that TSE surveillance should be targeted toward. However, these population figures are not detailed enough to estimate rates for cattle that experience clinical signs compatible with a TSE. Take, for example, deaths from unknown cause comprising 51,735 dairy cows and 103,180 beef cows from Table 1. An unknown cause may range from just being found dead to remaining unknown after a thorough diagnostic work up by the producer's veterinarian. Again, etiologies for cattle who died showing central nervous system (CNS) signs (6623 dairy cows, Table 1) may include dozens of known diseases that may have been definitively diagnosed by a veterinarian along with some unknown CNS causes.

Compatible signs of a TSE include progressive neurological clinical signs such as gradual paralysis, behavior changes, abnormal gait, or other recognizable CNS signs before death. However, here in the U.S., we have no precise estimate of the size of this cattle population. If a TSE were present in the U.S. cattle population, defining and then sampling from a narrow population of cattle that exhibit signs compatible with a TSE would produce the greatest probability of establishing the existence or absence of the disease for a given sample size.

Table 1. U.S. adult cow statistics from USDA/NASS data, the NAHMS Dairy '96 and Beef '97 reports are shown

	Dairy	Beef
Total population	9,199,000	33,885,000
Died pre-harvest	349, 562	508,275
Died from unknown cause	51,735	103,180
Died showing CNS signs	6,623	unknown

Currently, one common term used for many non-ambulatory cows is "downer-cow". If a TSE was present in U.S. cattle, affected animals might exhibit clinical signs that would be simply described by some as "downer-cows". However, the "downer-cow" syndrome encompasses non-neurological events plus cases with progressive or non-progressive neurological clinical signs. A better description of this syndrome is needed.

Bovine veterinary practitioners are a source for a more specific estimate of the number of cows that exhibit clinical signs that might be compatible with a TSE disorder in the preharvest stage. This is because bovine veterinarians would be expected to be called to examine a percentage of non-ambulatory and neurologic cases (i.e., cows exhibiting clinical signs potentially consistent with a TSE) and make a diagnosis.

The first objective of this study was to collect data from practicing veterinarians that would describe non-ambulatory or "downer-cows" in the U.S. cattle population. A second objective was to estimate rates for neurological conditions potentially compatible with a TSE and determine if these rates were affected by regional and herd-size differences. The design of this study was to survey veterinary members of the American Association of Bovine Practitioners (AABP) and compile the data regarding down cows as reported from their clients' dairy and beef herds.

Materials and Methods

Through the questionnaire, practitioners were asked to report the number of non-ambulatory beef and dairy cows (>20 months old) they had seen in their clients' cattle herds and those that were exhibiting known or unknown but non-progressive CNS clinical signs during the previous six months. Further, they were also

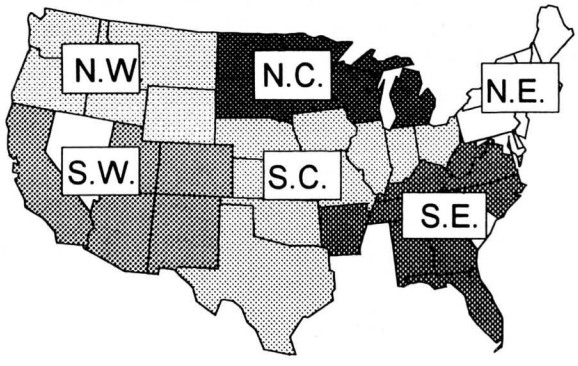
requested to report the number of beef and dairy cows (>20 months old) they had seen in their clients' cattle herds that were exhibiting progressive CNS clinical signs during the previous six months. Respondents were directed to place each of these cases into one of the following diagnostic categories: injury/trauma, non-responsive milk fever, neoplasia, known infectious agent, septicemia/toxemia, other known neurological condition or unknown neurological condition. Finally, they were asked for the number of cows that recovered. A copy of the questionnaire is available upon request from the authors.

The questionnaire was mailed to all AABP members in September 1998. It was also placed on the member-only section of the AABP web site from which responses were sent directly to one of the authors. Additional questionnaires were handed to attendees at the AABP Annual Meeting in Spokane, WA, in September 1998. The last response was received on November 15, 1998.

Data were used to estimate rates for potential TSE-compatible CNS conditions. Percentages of total cases were calculated for each cause. Total number of cases were also expressed as a percent of the cow population for each breed. Rates were calculated as cases/million cow years at risk.

Data were grouped by geographic location into regions and analyzed for differences. The geographic regions were similar to those used by the USDA/CEAH investigators for their dairy and beef cattle NAHMS surveys during the 90's. Regions were Northwest (N.W.), Southwest (S.W.), North central (N.C.), South central (S.C.), Northeast (N.E.) and Southeast (S.E.) (Figure 1).

Figure 1. Grid marks and shading show the different region areas used in this study.



Since it was thought that the number of cows in a herd size may be a factor in rates, the data were analyzed for all categories by herd size. Dairy data were divided into herds with 1-49 cows, 50-99 cows, 100-199 cows and >200 cows. Beef data were divided into herds with 1-49 cows, 50-99 cows, 100-299 cows and >300 cows. These divisions were selected to match the NASS herd size divisions for dairy and beef cattle populations.

To assess the sensitivity of testing for a TSE in some regions and herd-sizes found in the data, combined dairy and beef rates were calculated. A potential TSE prevalence of one case per million ($1/10^6$) was assumed as the desired detection level. A TSE rate of $1/10^6$ was assumed to potentially exist in each specific population examined. The potential incidence of a TSE in the specific population was calculated as: TSE rate$1/10^6$ ÷ combined case or non-recovery rate of cows in that population. Suggested minimum numbers of brains required for TSE detection were calculated based on a test sensitivity of at least 50%. While experts would agree that the diagnostic tests for TSE have sensitivities greater than 50%, the true level of test sensitivity is unknown. Therefore, a value of 50% was used to provide minimum case data. The minimum number of tests needed for each category to detect a TSE rate of $1/10^6$ were also calculated.

For statistical analysis of all data, rates were compared by Chi-square pair-wise analysis for differences. Fischer's exact Chi-square test was used when there were less than five cases listed for a cause event. P-value of <0.05 was considered as displaying a significant difference. Standard errors for percentages and rates were calculated and are available upon request from the authors.

Results

Responses were received from 792 veterinarians in 38 states. There were reports from 19,249 dairy herds with a total of 2,021,839 dairy cows >20 months of age. The median dairy herd size was 104 cows. There were reports from 16,145 beef herds totaling 1,688,337 beef cows >20 months of age. The median beef herd size was 69 cows.

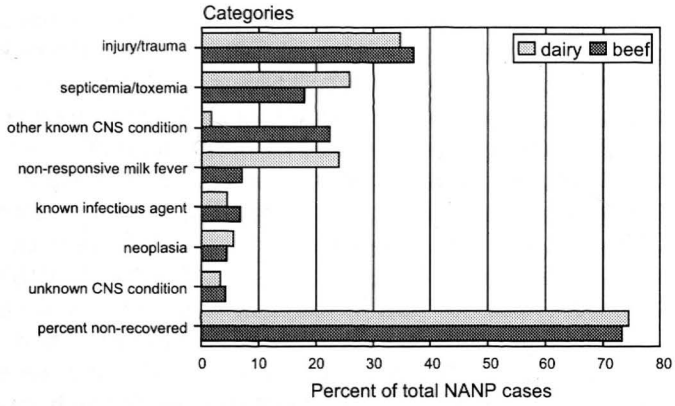
1. Analysis of non-ambulatory cases, with non-progressive CNS clinical signs (NANP)

A profile of an NANP dairy cow. The frequency of specific diagnoses was used to describe the NANP dairy cow population. Of the 2,021,839 dairy cows in the study, 5121 (0.25%) developed an NANP disorder, for a case rate of 5066 animals/10^6 cow years or 10^6 cows/year. Of these, 3813 (74.3%) failed to recover. In the study, the non-recovery rate, from now on named mortality rates, was 3772/10^6 cows.

There were 168, or 3.3% of the total dairy NANP cases, that remained undiagnosed. This implies that 97% of the NANP dairy cows presented to veterinarians in this study were diagnosed. The unknown NANP case rate was 160 cases/10^6 dairy cows.

Trauma/injury, septicemia/toxemia and non-responsive milk fever cases made up the majority (85%)

Figure 2. Summary of dairy and beef data for all categories of non-ambulatory, non-progressive (NANP) cases observed by veterinarians in the study. Cause values were expressed as percent of total NANP cases for each breed.



of animals who became moribund with an NANP disorder. This majority element of the profile remained very constant, expressing itself in regional data and herd size data analysis as well. The balance of choices accounted for 12%, excluding unknown cases, which fill the profile with 3% (Figure 2).

A profile of an NANP beef cow. The data were also used to describe the NANP causes in the study's beef cow population. This beef cow population also had a low incidence of NANP cases. Of the 1,688,337 beef cows in the study only 0.12% of cows (2090) developed an NANP disorder for a case rate of 2476/10^6 cows. Seventy-three percent (1535) failed to recover. The NANP mortality rate was 1818/10^6.

Just 89 cows remained undiagnosed or 0.0053% of the beef cow population. That is, 4.3% of all beef NANP cases were unknown or undiagnosed. This implies that 96% of these cases presented to veterinarians in this study were diagnosed. The unknown NANP case rate for beef cows in this study was 106/10^6 beef cows/year.

Trauma/injury, septicemia/toxemia and other known CNS cases made up the majority (78%) of animals who developed an NANP disorder. This majority element of the profile for NANP beef cows remained very constant, expressing itself in regional data and herd size data analysis as well. The balance of diagnostic choices accounted for 18%, excluding unknown cases, which fill the profile with 4% (Figure 2).

2. Analysis of progressive CNS cases

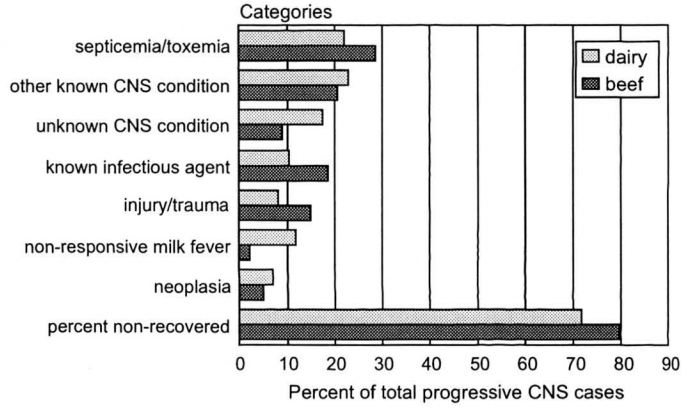
Progressive CNS dairy cases. There were 536 total progressive CNS cases reported for dairy cattle, 0.027% of the total number of dairy cattle in the study. The total-case rate was 554/10^6. Of these, 17.7% (95/536) were unknown or undiagnosed suggesting that 82% of progressive CNS dairy cases presented to veterinarians in this study were diagnosed. The 95 progressive CNS cases of unknown cause were 0.0047% of the study's dairy cattle population, or a rate of 94 cases/10^6 dairy cows. Seventy-one percent (379) of the cases failed to recover, for a mortality rate of 375 deaths per million dairy cows in the study (Figure 3).

A profile of a progressive CNS dairy case. The general profile of the progressive CNS cases in dairy cattle found that other known CNS conditions, septicemia/toxemia, unknown CNS conditions and non-responsive milk fever to be the most frequently reported causes, accounting for 75.0% of the total cases. Known infectious agent cases totaled 9.6% of the causes. The balance of diagnostic choices accounted for 15.4% (Figure 3).

Progressive CNS beef cases. There were 298 progressive CNS cases reported by veterinarians in beef cattle, or 0.018% of the total number of beef cattle in the study. Of these, 9.06% (27/298) were of unknown etiology suggesting that 91% of progressive CNS beef cases presented to veterinarians in the study were diagnosed. The unknown progressive CNS case rate was 32 cases/10^6 beef cattle. There were 238 total deaths in beef cows showing progressive CNS signs for a mortality rate of 282/10^6.

A profile of a progressive CNS beef case. In beef cattle four case categories accounted for 83.4% of the total reported causes: injury/trauma, known infectious agent, septicemia/toxemia and known CNS condition. The overall data described a beef-cow profile that was similar to the NANP beef-cow profile. The progressive CNS beef-cow profile remained similar throughout regional and herd-size analysis (Figure 3).

Figure 3. Summary of dairy and beef data for all categories of progressive CNS cases observed by veterinarians in the study. Cause values were expressed as percent of total progressive CNS cases for each breed.



3. Regional analysis

Cattle population demographics. When the data were analyzed by regions, the distribution of dairy and beef cows and relative herd sizes appeared to parallel the demographics reported by USDA/NASS.

NANP regional dairy cases. In all regions, the three most frequently reported NANP causes remained the same as reported for overall data. The balance of this report will describe changes in unknown neurological case rates and mortality rates for non-progressive and progressive CNS cases as affected by regions and/or herd-size.

The percentage of unknown NANP cases in dairy cattle varied among regions. However, only values for the N.C. (1.9%) and S.E. (5.5%) regions were found statistically different from other areas. The unknown case rates for the S.W., N.C. and S.E. regions were found statistically different from other regions (Table 2).

Progressive CNS regional dairy cases. For progressive CNS cases, the percentage values of unknown cases in dairy cattle ranged from 4.2% in the S.C. area to 25.5% in the N.E. Only the low value of 4.2% in the S.C. region was found statistically different from other regions. The unknown case rates in the N.E. and S.E. regions were found statistically different from the other regions (Table 2).

For regions, the risk for developing a progressive CNS disorder, expressed as percent of total progressive CNS cases of the regional cow population ranged from 0.01% in the N.W. to 0.06% in the S.E. The lowest mortality rate (220 cases/10^6) was in the N.W. while the S.E. had the highest mortality rate with 1028 cases/10^6 cows in the region (Table 2).

NANP regional beef cases. For beef cows, the percentage of CNS cases of unknown cause were statistically lower in the N.W. (1.5%). No other regional differences were detected (P>0.15). The case rates for unknown CNS causes were statistically lower in the N.W. and N.E. regions at 26 and 34 per million. No other regional differences were detected (P>0.15) (Table 3).

Progressive CNS regional beef cases. The values for the percent of unknown cases in beef cattle ranged from 0% in the N.W. to 25.0% in the S.W. Values in the N.W., S.W. and S.E. were found statistically different from other regions. The unknown cause case rates for the N.W. and S.E. were statistically different (Table 3).

The total percentage of progressive CNS cases in beef cattle varied between 0.007% in the S.W. to 0.04% in the N.E. and were found statistically different from other regions. Beef cows in the S.E. region had the highest mortality rate for total progressive CNS cases with 560/10^6 cows. No other regions were found statistically different (Table 3).

4. Herd-size analysis

Demographic herd-size analysis. Overall, the percentages of dairy and beef cows in each herd-size group were comparable to USDA/NASS data for herd size category percentages. The percentages for dairy and beef herd numbers were reflecting USDA/NASS values.

NANP dairy herd-size cases. The percentage of unknown NANP causes in dairy cattle varied among herd sizes. The lowest and highest values were statistically different from other herd-size groups. The lowest value (1.8%) was in the 100-199 herd-size group and the highest value (5.3%) was in the >200 herd-size group. The highest unknown case rate was in the smallest size herds with 364 per million cows and was the only rate statistically different from other rates (Table 4).

Table 2. The percentages of non-progressive and progressive unknown CNS cases and the mortality rates/million for dairy cows experiencing progressive CNS signs in dairy cattle. * A letter next to any category indicates a statistical difference from other values (P<0.001)

	Non-progressive dairy cases		Progressive dairy cases		
Regions	Percent of total cases for unknown causes	Unknown cause case rate/10^6	Percent of total cases for unknown causes	Unknown cause case rate/10^6	Mortality rate/10^6 for cows with progressive CNS signs
Northwest	3.1	120	15.3	40	220
Southwest	4.3	204[b]	17.5	52	288
North central	1.9[a]	78[a]	15.8	58	326
South central	2.4	146	4.2[a]	34	480[a]
Northeast	2.9	158	25.5	204[a]	542[a]
Southeast	5.5[b]	432[c]	20.3	228[a]	1028[b]
Overall	3.3	160	17.7	94	398

Table 3. The percentages of non-progressive and progressive unknown CNS cases and mortality rates/million for beef cows experiencing progressive CNS signs in beef cattle. * A letter next to any category indicates a statistical difference from other values (P<0.001)

	Non-progressive beef cases		Progressive CNS beef cases		
Regions	Percent of total cases for unknown causes	Unknown cause case rate/10^6	Percent of total cases for unknown causes	Unknown cause case rate/10^6	Mortality rate/10^6 for cows with progressive CNS signs
Northwest	1.5[a]	26[a]	0.0[a]	0[a]	204
Southwest	2.5	106	25.0[b]	44	178
North central	2.7	64	6.1	22	326
South central	6.9	134	6.4	28	308
Northeast	1.9	34[a]	4.7	34	296
Southeast	4.5	138	21.3[b]	68[b]	560[a]
Overall	4.3	106	9.0	32	534

Table 4. Percent of total cases and rates/10^6 for unknown NANP causes and percent of total cases, rates/10^6 for unknown causes and mortality rates from progressive CNS causes for dairy herds with 1-49 cows, 50-99 cows, 100-199 cows and 200 cows or more. * A letter next to any category indicates a statistical difference from other values (P<0.001)

	Non-progressive dairy cases		Progressive CNS dairy cases		
Number of cows in herd	Percent of total cases for unknown causes	Unknown cause case rate/10^6	Percent of total cases for unknown causes	Unknown cause case rate/10^6	Mortality rate/10^6 for cows with progressive CNS signs
1-49	3.5	364[a]	12.1	148[a]	840[a]
50-99	3.9	158	14.4	82	380
100-199	1.8[a]	72	17.5	70	330
>200	5.3[b]	184	22.9	80	322
Overall	3.3	160	17.7	94	398

Progressive CNS dairy herd-size cases. In the category of progressive CNS cases, there were some differences noted. The percentage values of unknown progressive CNS cases varied, however, no value was found statistically different, at a P-value >0.15. When looking at case rates, the largest unknown case rate was in herds with 1-49 cows at 148/10^6 cows and was statistically different from other case rates. The mortality rate for total cases was statistically different in herds with <50 cows at 840/10^6 cows, more than double other rates. P-values for other herd-size differences were >0.15 (Table 4).

NANP beef herd-size cases. The percentage of unknown NANP cases in different sizes of beef herds varied. Only the high value in herds of 50-99 cows (7.6%) was found statistically different from others. The unknown case rates for herds of 1-49 and 50-99 cows were statistically different from other herd-size groups, 160/10^6 and 192/10^6, respectively.

Progressive CNS beef herd-size cases. The values for the percent of unknown progressive CNS cases in beef cattle varied, however none of the herd-size percentages for unknown CNS cases were found statistically different from each other (P-value >0.15). It was noted that the number of cows in each herd group for the unknown progressive CNS case category was small. The unknown progressive CNS case rate for herds with 1-49 cows (64/10^6) was statistically different from other unknown rates (Table 5).

The percentage of total progressive CNS cases varied. The highest values were in the smallest herd-size groups and were statistically different from other percentages. The smallest value (0.006%) was in the larg-

Table 5. Percent of total cases and rates/10^6 for unknown NANP causes and percent of total cases, rates/10^6 for unknown causes mortality rates from progressive CNS causes for beef herds with 1-49 cows, 50-99 cows, 100-299 cows and 300 or more cows. * A letter next to any category indicates a statistical difference from other values ($P<0.01$)

	Non-progressive beef cases		Progressive CNS beef cases		
Number of cows in herd	Percent of total cases for unknown causes	Unknown cause case rate/10^6	Percent of total cases for unknown causes	Unknown cause case rate/10^6	Mortality rate/10^6 for cows with progressive CNS signs
1-49	3.5	160[a]	9.5	64[a]	466[a]
50-99	7.6[a]	192[a]	7.5	44	486[a]
100-299	4.5	62	6.1	20	170
>300	2.9	40	10.1	12	136
Overall	4.3	106	10.3	32	282

est herd-size group and was also statistically different from other total case values. Mortality rates were statistically different in herds with 1-49 cows (466/10^6) and herds with 50-99 cows (486/10^6) (Table 5).

5. Minimum number of tests required for TSE detection

Since "downer-cows" presented at slaughter may be either NANP cows or cows with subtle progressive CNS signs that went down enroute, the combined expected dairy and beef rate or risk is 4337/10^6 for cows from farms in this study. If 400 brains were taken randomly from these cows, the current testing methods could detect a rate of six cases of TSE/10^6 cows each year. The combined mortality, or non-recovered progressive CNS rate was 913 cases/10^6 cows in the southeast. The minimum number of brains required to be tested was 460 from that population to detect a TSE rate of 1/10^6. However, 400 brains tested could have detected a TSE rate of 2/10^6 (Table 6).

Discussion

The survey was designed to elicit responses from bovine veterinarians in clinical practice. At the time of the survey, there were approximately twenty-eight hundred AABP members in private clinical practice in the United States. Approximately 28% (792) of these private practitioners responded to the questionnaire. Information from respondents could have been collected from written client records, from memory or other less precise information source. This may have introduced some selection or reporting bias into the data. However, it was interesting that the demographic information on herd size and cow numbers reported in this survey mimicked cattle statistics reported by USDA/NASS for each state.

Common knowledge, and other surveys among producers and veterinarians, tell us that veterinarians may not see every sick cow in a particular client's herd. An incorrect diagnosis for a variety of reasons in any category was possible for some individuals. This survey did not require diagnoses to be dependent on laboratory confirmation. Therefore, case frequencies and rates reported in this study should be considered as estimates of the true values. Actual frequencies may have been under or over those reported here. An expected outcome from a survey of this type is data that can be used to aid in developing hypotheses that can be tested with more information.

Reporting on the "downer-cow". One of the objectives of this survey was to better define the "downer-cow". The data revealed a consistent but separate profile for dairy and beef cows. For dairy cows, most of the cases fell into three cause categories: injury/trauma, septicemia/toxemia or non-responsive milk fevers. For beef cows, other known CNS disorders replaced the non-responsive milk fever cases for most of NANP cows. This might have been expected since milk fever is not common among beef herds and hypomagnesemia, salt or nitrate poisoning might be. Veterinarians diagnosed between 92% and 98% of these cases.

Although the profile describing cows with progressive clinical CNS signs was not as consistent in all regions as NANP cases, it was very consistent throughout herd size divisions. A striking feature of the progressive CNS dairy cow profile was the large percent of undiagnosed cases, ranging between 10% and 25% of all progressive CNS cases reported, depending on region or herd size. Therefore, the percent of diagnoses for progressive CNS cases fell below the NANP levels. Practitioners di-

Table 6. Examples of combined beef and dairy NANP, unknown and non-recovered progressive CNS rates, potential TSE percent incidence in selected populations, maximum TSE rate expected after 400 TSE-negative tests/year in that population and minimum number of tests required to detect a TSE in specific population, occurring at a rate of $1/10^6$ per year.

Selected population categories from this study, wherein cows might exhibit CNS signs compatible with a TSE	Combined dairy and beef rate/10^6 in study cows	Potential TSE incidence just in this category	Maximum TSE rate/10^6 expected after 400 TSE-negative brains tested	Minimum number tested in this population to detect a TSE rate of $1/10^6$
unknown NANP cases	139	0.719%	0.2	70
unknown NANP cases in the S.E.	259	0.386%	0.4	130
unknown NANP cases in herds <50 cows	251	0.398%	0.4	130
non recovered progressive CNS cases	341	0.293%	0.5	180
non recovered progressive CNS cases in the S.E.	913	0.110%	2.0	460
non recovered progressive CNS cases in < 50-cow herds	634	0.158%	0.8	320
unknown progressive CNS cases	66	1.515%	0.1	33
unknown progressive CNS cases in the S.E.	134	0.373%	0.2	70
unknown progressive CNS cases in herds <50	101	0.909%	0.2	55

agnosed between 75% and 90% of cases depending on the region and/or herd-size.

The risk for beef and dairy cows being a progressive CNS or an NANP case was less than 0.60% of the total number of cows in the study. The percent of total NANP cases ranged from 0.07% to 0.57%. The percent of total progressive CNS cases, whose clinical signs would be most compatible with a TSE, were even lower. Percent of total progressive CNS cases ranged from 0.007% to 0.07% of the total cow populations in the study for each breed. These percentages may underestimate the true value since veterinarians may not examine all cows exhibiting these categories. This may be especially true for large dairies with >1000 cows.

Frequency of unknown and progressive CNS causes. A second objective of this study was to collect data describing cows with progressive neurological signs, potentially compatible with a TSE, and determine if estimated rates were affected by regional and herd-size differences. Regionally, dairy cows in the southeast and southwest had the highest rates for unknown NANP cases and the northeast and southeast regions had the highest rates for unknown progressive CNS cases. While mortality rates for progressive CNS cases were >400/10^6 in the south central and northeast regions, dairy cattle in the southeast, with the highest unknown CNS case rate and highest mortality rate, were at the greatest risk for progressive and unknown CNS disorders. The same was found for beef cows in the southeast. They were at highest risk for unknown and total progressive CNS cases. Further study to better clarify the situation in the southeast may be warranted.

Results of the herd-size analysis showed that dairy herds with <50 cows and beef herds with <100 cows had the highest incidence for unknown NANP plus unknown and total progressive CNS cases in this study. Their rates were nearly twice the rates in other herd groups. Further study of small beef and dairy herds is advised, especially assessing the possible relationship with regional data as herd-sizes within regions may have influenced regional outcomes.

Surveillance for a potential TSE case. At first glance one might decide to look past the NANP population of neurological disorders for any cases of TSE. Perhaps the non-progressive nature of these cases, i.e., their commonly abrupt appearance and resolution make them poor suspects for the more progressive and insidious character of natural and experimental spongiform diseases described in cattle. However, one might consider the non-progressive unknown CNS cow population for closer examination. Since the cause of their neurological condition is undiagnosed, testing for a TSE in this population may help to eliminate them from a suspect list. Overall, cases of unknown, non-progressive CNS conditions were only 3.3% of all NANP cases for a case rate of 166/10^6 cows in the general population, although the unknown CNS case rate for NANP dairy cattle was higher in some regions (i.e., N.E. and S.E.) and in small herds.

Current surveillance methods are designed to detect the presence of a TSE. An unproven theory is that a TSE may spontaneously occur in U.S. cattle at a rate of one case/10^6 cow years or one case/10^6 cows every year. The rate would probably be higher if a TSE was being transmitted to other animals. With present surveillance

methods, approximately one third of the samples were taken from "downer-cows" at slaughter. Since "downer-cows" may be either NANP cows or cows with progressive CNS signs, the combined expected rate or risk was $4337/10^6$ for cows in this study each year. If, for an example, 400 brains were randomly tested from these cows, a test with at least a 50% sensitivity could have detected a rate of six cases of TSE/10^6 cows each year. If this sampling were to become more specifically targeted to "downer-cows" with unknown neurological conditions, it may increase the ability to detect a TSE rate of one per million in U.S. cattle. For example, this survey detected a combined rate of $251/10^6$ for unknown NANP cases in small (<50) dairy and beef herds. Assuming a test sensitivity of at least 50%, the minimum number of brains that would have to be tested in this population to detect a $1/10^6$ TSE rate would be 130.

Progressive CNS disorders. TSE diseases, as described in cattle, generally are expressed as progressive in character. Therefore, it seems likely that random, on-the-farm or at slaughter sampling of non-recovered cattle that expressed progressive CNS signs would yield the best probability of detecting a TSE if it existed. The overall combined dairy and beef rate of these non-recovered progressive CNS cases ($341/10^6$) would suggest that at least 180 randomly collected, non-recovered progressive CNS cases could detect a TSE rate of $1/10^6$. However, size differences for dairy and beef herds would suggest a higher number of tests. The rate of $634/10^6$ for small herds would suggest a minimum of 320 brains, randomly collected from small-herd cases, to detect a potential TSE case in that population. Surveillance in the southeast, where the combined rate is $913/10^6$, would require 460 brains tested to detect a TSE rate of $1/10^6$ in that sub-population.

If, on the other hand, one was to randomly sample only the undiagnosed progressive CNS cases in small herds, 55 tests could detect a case of TSE. If surveillance was to be stratified by regions, a minimum number of 70 randomly collected specimens from unknown progressive CNS cases would be required for the southeast.

Conclusions

The data gave a usable description of the progressive CNS population and of the non-ambulatory, non-progressive (NANP) "downer-cow" population. Veterinarians diagnose 90% or more of the NANP cows and 75% or more of the progressive CNS cases they examine. This suggests that the total number of "downer-cows" in the U.S. is not equivalent to total number of cows at risk for having a TSE. Most of the "downer-cows" in this survey had specific diagnostic syndromes. The data supports the concept that there are regional and herd-size impacts on the risk of cows being a case. Surveillance efforts could be modified to detect a potential TSE in high and low risk regions and high and low risk herd-size groups to supplement current national level effects.

Acknowledgments

Special thanks to: Linda Detwiler, USDA/APHIS Emergency Program Staff; Barrett Slenning, North Carolina State University; David Dargatz, USDA/APHIS/VS/CEAH; Dale Hancock, Washington State University and members of the AABP Food Safety Committee for their help and contributions to this article.