DESIGN OF THE 1994-95 UNITED STATES CATTLE ON FEED EVALUATION

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Abstract

The 1994 Cattle on Feed Evaluation was a cooperative, USDA-sponsored project involving Washington State University, the National Veterinary Services Laboratories, the National Animal Disease Center, the National Agricultural Statistics Service, state agricultural departments, and the Animal and Plant Health Inspection Service:Veterinary Services. The project focused on cattle on feed operations in 13 states that accounted for over 85 percent of the industry. Operations in the study were selected from National Agricultural Statistics Service list frames. Questionnaires were administered by telephone to operations with a one-time capacity of fewer than 1,000 cattle. Larger operations were visited twice to administer questionnaires. A subsample of the larger operations was selected for *E. coli* 0157:H7 and *Salmonella* fecal testing. Multivariate analyses identified factors associated with the detection of these bacteria in feedlot pens. In addition, data summarized from this national study can be used to evaluate the impact of management practices on cattle on feed operations.

1. Introduction

Baseline evaluations of animal health, productivity, and management are important to agricultural producers and the professionals who serve them (King, 1990). Baseline measurements provided by producer surveys permit individual producers to assess the productivity of their operations, and to compare their production systems with those of other producers (Dargatz, 1994). Survey results also allow teachers and researchers to have a better understanding of current management practices and problems on commercial livestock operations (Heinrichs et al., 1994).

In addition, survey-based epidemiological studies of domestic animals serve to evaluate or to establish the existence of associations between an observed condition and various characteristics of the animals' management and environment (Martin et al., 1987). These studies support those working with producers to address health-related herd problems (Leech, 1971).

The United States Department of Agriculture (**USDA**):Animal and Plant Health Inspection Service (**APHIS**):Veterinary Services (**VS**), National Animal Health Monitoring System (**NAHMS**) was created to address the animal health information needs of producers, consumers, agribusiness, academia, and animal health regulatory officials in the United States (Hueston, 1990). The 1994 Cattle on Feed Evaluation (**COFE**) was the fourth national survey of the NAHMS program. The primary objective of the COFE was to identify management practices being employed in feedlots throughout the major cattle feeding regions of the United States.

2. Materials and methods

2.1. Information needs assessment

The purpose of the information needs assessment was to establish the study objectives. The study objectives were determined from the priorities identified by the study's key stakeholders, including the National Cattlemen's Beef Association, veterinary organizations (the Academy of Veterinary Consultants and the American Association of Bovine Practitioners), USDA:APHIS:VS National Cattle Diseases Staff, and regional and area USDA:APHIS:VS staff. In addition, Rockwood Research conducted a survey of feedlot operations which had marketed between 100 and 1000 cattle during 1992 to assess their information needs. From the most important information needs identified, descriptive report table shells were developed. The descriptive report table shells, in turn, served as the basis for creating survey questionnaires.

2.2. Study design and implementation

The study design was a joint effort between the USDA:APHIS:VS,Centers for Epidemiology and Animal Health (**CEAH**) and the USDA:National Agricultural Statistics Service (**NASS**). NASS collects and reports feedlot inventory information from surveys monthly in seven states (Arizona, California, Colorado, Iowa, Kansas, Nebraska and Texas) and quarterly in six more states (Idaho, Illinois, Minnesota, Oklahoma, South Dakota and Washington). Participation in the COFE was limited to these 13 states, which accounted for 85.8% of the January 1, 1994 cattle inventory on feedlots in the United States (Glenda Shepler, USDA:NASS,Agricultural Statistics Service Board). Three states (Texas, Nebraska and Kansas) accounted for more than half of the total inventory. During 1993, cattle on feed operations with a one-time capacity of fewer than 1,000 cattle accounted for 96.0% of the operations, but marketed only 12.7% of the feedlot cattle in the 13 participating states (Cattle on Feed Report No. Mt

An 2-1 (2-94), released February 18, 1994 by the USDA:NASS:Agricultural Statistics Board).

2.2.1. Sample selection

Producers selected for inclusion in the COFE were a subset of producers selected for the NASS Cattle on Feed Survey. Producers selected for the NASS Cattle on Feed Survey were, in turn, a subset of the producers that had been selected for the January 1, 1994 NASS Cattle and Sheep Report. The NASS list sampling frame was based on any information which NASS could obtain (for example, previous surveys and, in some states, state agricultural census records). No area sampling frames were used.

The January 1, 1994 NASS Cattle and Sheep Report's stratification was based on a mix of size groupings by selected control variables by state on the NASS list sampling frame. The control variables were determined by cattle on feed (one time capacity), number of sheep, milk cows and total cattle. Operations were assigned to the highest stratum number possible.

To support the NASS Cattle on Feed Estimation Program, NASS selected a subset of the operations that had been selected for the NASS Cattle and Sheep Report. The list sampling frame was re-stratified based on cattle on feed capacity data. Sample sizes for the NASS Cattle on Feed Estimation Program were established at the stratum level within each state. NASS created a total of 108 sampling strata for the program.

Within each NASS Cattle on Feed Estimation Program stratum, operations were sorted from largest to smallest. Operations that had refused to participate in the NASS Cattle and Sheep Report or that had been inaccessible during data collection for the NASS Cattle and Sheep Report were included at the end of the sort. Cattle on feed operations that were known not to have had any cattle or that were known to have been out of business (based on information gathered at the time of interview for the NASS Cattle and Sheep Report) were disqualified from taking part in the NASS Cattle on Feed Estimation Program. Chromy's procedure, which is a sequential procedure for probability minimum replacement sampling, was used to select the sample of operations for the NASS Cattle on Feed Estimation Program (Chromy, 1981).

Finally, the cattle on feed operations for the COFE were selected from among those operations that had been selected for the NASS Cattle on Feed Estimation Program. Generally, the largest producers in each state were selected with certainty. For strata comprising smaller producers, approximately one-half of the producers that had been selected for the NASS Cattle on Feed Estimation Program were randomly selected for inclusion in the COFE.

2.2.2. Promotion

Prior to the launch of the survey, NASS sent a letter and an informational brochure on the COFE to producers selected for participation in the COFE. The letter mentioned the endorsement of the study by the National Cattlemen's Association and of the president-elect of the American Association of Bovine Practitioners. Producers participating in the survey were promised fact sheets containing national results. Producer participation in the COFE was voluntary and information provided was confidential.

2.2.3. Pre-test

The COFE survey instruments were pre-tested in May and August, 1994.

2.2.4. Training

A VS coordinator was assigned for each participating state in February, 1994. The 13 VS state coordinators received training on the study objectives and the use of the survey instruments prior to training the data collectors in each of their states.

2.3. Data collection

The COFE consisted of two phases.

2.3.1. Phase 1 data collection

During the first phase of the COFE (August 1 to September 16, 1994), NASS telephone interviewers contacted selected cattle on feed operations identified as having a one-time capacity of fewer than 1,000 cattle. In addition, NASS enumerators visited larger operations to administer questionnaires. If the operator of an operation with a one-time capacity of 1,000 or more cattle indicated his willingness to continue in the study by signing a consent form, NASS turned the operator's name over to VS for Phase 2. All operations with a one-time capacity of 1,000 or more cattle that had participated in Phase 1 were entitled to participate in Phase 2, provided they remained in business and had cattle at the time of the Phase 2 visit.

2.3.2. Phase 2 data collection

From October 3 to December 21, 1994, a state or federal veterinary medical officer visited each operation whose operator's name was given by NASS to VS. The veterinary medical officer administered a questionnaire relating to the health management practices employed on the operation, and, in a convenience sample of 100 operations, collected fecal specimens for laboratory evaluation for the presence of *E. coli* 0157:H7 and *Salmonella* spp. For *Salmonella* testing, up to 25 fecal specimens were collected from each of two pens (the pen with the most recent arrivals, and the pen where cattle had been on feed the longest period of time) per feedlot. Information particular to these pens (for example, number of types of cattle in the pen, size of the pen, and feeds fed in the previous 7 days) was also collected.

2.4. Data entry and validation

2.4.1. Phase 1 data entry and validation

NASS data entry specialists entered data collected by NASS enumerators into a database and validated the data according to specifications furnished by CEAH. The identities of all respondents were protected. NASS did not reveal to VS the identity of any operation with a one-time capacity of fewer than 1,000 cattle nor of any larger operation that, during phase 1, did not consent to participate in the second phase of the study.

2.4.2. Phase 2 data entry and validation

CEAH staff entered data collected by visiting veterinary medical officers and animal health technicians into SAS data sets. Validation included assuring that subtotals added correctly, percentages added to 100 (where required), skip patterns were followed correctly, and that data were within expected ranges. Data outside expected ranges were verified personally by state coordinators and, where necessary, the veterinary medical officers.

2.5. Participation analysis

A chief purpose of the participation analysis was to examine whether information reported from the COFE might have been biased in some way due to differences between COFE participants and those operations that had either refused to participate in the study or had not been accessible when contact was attempted.

2.5.1. Phase 1 participation analysis

Participation rates were computed by state and feedlot capacity. The results were tested for significant differences ($p<0.05$) using the chi-square test in SAS's FREQ procedure (SAS, 1990).

2.5.2. Phase 2 participation analysis

Participation rates by a number of key variables (from the Phase 1 questionnaire) were computed and tested for differences using the chi-square test in SAS's FREQ procedure (SAS, 1990). The TTEST procedure of SAS (SAS, 1990) was used to compare mean death loss between Phase 2 participants and non-participants.

2.6. Weight creation

The purpose of sample weights is to derive accurate population estimates from survey data (Cochran, 1977). An operation's sample weight is the number of cattle on feed operations (in the population) which a sampled operation is representing for the purpose of creating population estimates from the study. Since smaller operations were sampled at a lower rate than large operations, smaller operations generally received a larger sample weight than larger operations.

2.6.1. Phase 1 weight creation

For each operation, the initial sample weight was the inverse of the sampling fraction in its NASS sampling stratum.

Phase 1 participants and operations in business but with no current inventory were treated the same for weight adjustment purposes. Both are called respondents.

Non-respondents included those operations that had not been accessible when contact for the COFE was attempted, or had refused to participate in the COFE when contacted.

To redistribute sample weights from Phase 1 non-respondents to respondents, a non-response adjustment factor was created for each of 23 poststrata. The poststrata were based on feedlot capacity and region, with ≥ 20 Phase 1 participants in each poststratum.

The non-response adjustment factor for each respondent was the sum of the initial sample weights of all respondents and non-respondents within its poststratum, divided by the sum of the initial sample weights of the respondents in its poststratum.

The product of the initial sample weight and the non-response adjustment factor yielded a non-response adjusted sample weight for each respondent.

Non-respondents received a non-response adjusted sample weight of zero. Weights of ineligible operations (i.e., operations that were out of business, and university, research, and other institutional feedlots) were not adjusted for non-response.

The weights were adjusted again to force the COFE estimate of the total number of cattle placed on feed from July 1, 1993 to June 30, 1994 to match the number published by NASS for each of eight region by feedlot capacity classes.

2.6.2. Phase 2 weight creation

Procedures similar to those described for Phase 1 were designed to redistribute Phase 1 sample weights from those operations that were entitled to participate in Phase 2 but did not participate in Phase 2 to those operations that participated in Phase 2.

2.7. National estimates

Population estimates (of means and proportions) and standard error estimates were obtained using SUDAAN, a program specifically designed for survey data analysis (Research Triangle Institute, 1992). SUDAAN uses first order Taylor series approximation to estimate standard errors (Research Triangle Institute, 1992).

2.8 Risk factor analysis

A chi-square test, using the FREQ procedure of SAS (SAS, 1990), was used to screen variables hypothesized to be associated with *Salmonella* shedding. Variables with $P < 0.20$ were considered for inclusion in a multivariable model. The CORR procedure of SAS (SAS, 1990) was used to obtain Spearman rank correlation coefficients between the screened variables to obtain awareness of potential multicollinearity. SUDAAN was used to build a multivariable logistic regression model, with the odds of observing a *Salmonella* positive pen serving as the dependent variable. Region was forced into the model to make certain that variables did not enter the model merely because of regional differences in management. Because a convenience sample was used, the analysis was unweighted. A P-value ≤ 0.05 was required to enter and remain in the model.

3. Results and discussion

3.1. Participation

3.1.1. Phase 1 participation

The NASS procedure selected 6,338 cattle on feed operations. More than half of the selected operations were not contacted because they had been known by NASS to have been out of business or to have had no inventory prior to the selection of the COFE sample. Although not contacted for the COFE, these operations remained on the list to be sampled for the purpose of maintaining their weights in the computation of national estimates of cattle on feed operations, so as to remain consistent with NASS procedures for computing national inventory estimates. NASS does continue to return to these operations for its cattle on feed reports.

Of the 2,489 qualified producers, 1,411 (57%) participated in Phase 1. This figure assumes that all of the operations that refused to participate in Phase 1 or were not accessible were qualified for the COFE (i.e., were in business and in scope at the time of attempted contact). No measure exists as to the extent to which this assumption is erroneous. Therefore, the computed Phase 1 participation rate may be conservative.

The Phase 1 participation rate was significantly higher ($p<.05$) among producers with a one-time capacity of fewer than 1,000 cattle than among producers with larger capacity. Of the 1,488 qualified producers with a one-time capacity of fewer than 1,000 cattle, 913 (61%) participated in Phase 1. Of the 1,001 larger qualified feedlot operations, 498 (50%) participated in Phase 1 of the COFE.

By state, Phase 1 participation ranged from 34.6% in California to 88.9% in Arizona.

3.1.2. Phase 2 participation

Of the 498 operations with a one-time capacity of 1,000 or more cattle that had participated in the Phase 1 of the COFE and that remained in business and had inventory at the time of the Phase 2 visit, 453 (91%) completed the second part of the study with the visiting veterinary medical officer. Ten declined during Phase 1 to have their names turned over to VS for Phase 2, 7 were not accessible, and 28 refused to participate when contacted for Phase 2.

Three operations had either gone out of business or had zero inventory at the time of the veterinary medical officer's visit, and were excluded from the Phase 2 participation analysis.

By state, Phase 2 participation rates ranged from 73% in South Dakota to 100% in Oklahoma.

Phase 2 participants were significantly more likely to have used a nutritionist than non-participants ($p<0.05$). Operations that had placed at least 2,500 cattle on feed from July 1, 1993 to June 30, 1994 had a significantly higher Phase 2 participation rate than operations that had placed fewer cattle. Differences in participation rates for the other categorical variables examined (e.g. placed any dairy cattle; placed both beef and dairy cattle; placed any cows or bulls; placed Mexican cattle; used a veterinarian; hide branded cattle) were not significant. The mean death loss rate from July 1, 1993 to June 30, 1994 for operations with 1,000 head or greater capacity that did not participate in Phase 2 was significantly lower ($0.88 \pm 0.12\%$) than the mean death loss rate for Phase 2 participants ($1.29 \pm 0.10\%$).

In general, the comparisons between Phase 2 participants and non-participants indicated that the differences were not great, and that the participants reflected reasonably well the sample selected.

3.2. National estimates

Based on the COFE data, national estimates for the cattle on feed industry have been tabulated (USDA, 1995). The national estimates apply to the cattle on feed operations in the 13 states included in the COFE.

3.2.1. Quality assurance and food safety concerns

Concerns about quality and food safety have had impacts on cattle feeders (Jones et al., 1992). The COFE revealed that $27.0 \pm 2.7\%$ of small feedlots and $83.0 \pm 1.4\%$ of larger feedlots reported some change in injection practices (i.e., site, route) in the five years prior to interview. Nearly three-fourths ($73.2 \pm 1.7\%$) of large feedlots reported a change in, or development of, quality assurance training for feedlot workers. For small feedlots, only $15.7 \pm 2.5\%$ reported similar actions. However, since many small feedlots may only employ the owner and the owner's family members, implementation of or changes to a quality assurance training program may have been irrelevant.

3.2.2. Branding practices

The hide is the single most important by-product of the cattle industry (Frye, 1995). Branding can result in loss of value to the hide, the amount of loss depending upon the location of the brand (Frye, 1995). Overall, 19.7 ± 1.4% of cattle placed in feedlots were branded at the feedlot, the most common location for branding being the upper rear leg or hip.

3.2.3. Clostridial injections

Injection site lesions represent a quality concern for the beef industry (Dexter et al., 1994). Much concern has centered around the use of clostridial vaccines, especially multivalent products. Of cattle on feed operations with a one-time capacity of 1,000 or more cattle, 91.0 ± 1.2% gave clostridial vaccinations, compared with 34.0 ± 3.1% of smaller operations. Of all cattle placed on feed from July 1, 1993 to June 30, 1994, 86.5 ± 1.1% received clostridial vaccinations.

Intramuscular injections have been demonstrated to be associated with tissue damage, and subsequent loss in value of the carcass (Dexter et al., 1994). For operations that used clostridial vaccinations, 38.0 ± 5.0% reported giving clostridial injections by the intramuscular route, and 70.0 ± 4.4% subcutaneously. The most common site for intramuscular clostridial vaccinations was the region of the neck and head (72.7 ± 5.3%).

Multiple vaccinations (at the same time or at different times) may increase the likelihood of an injection site lesion, which diminishes the value of a carcass. For operations where clostridial vaccinations were given, 22.8 ± 1.5% of cattle received more than one clostridial injection.

3.3. *Salmonella* risk factor analysis

Salmonella is an important pathogen to both cattle (Williams, 1980) and humans (Bean and Griffin, 1990). From 1983 to 1987, *Salmonella* accounted for 28% of foodborne disease outbreaks and 45% of foodborne disease cases of known etiology (Bean and Griffin, 1990).

Regionally, *Salmonella* was recovered from 43.9% of the pens in the Southern states, compared to 21.0% of pens in the Middle region and 5.9% of pens in the Northern region. From October to December (the period of Phase 2 data collection), the northern states are generally cooler than the southern states. As salmonellae multiply optimally at 37°C in moist environments, regional climatic differences may play a role in the survival and multiplication of *Salmonella* in cattle feces.

Feeding whole cottonseed or cottonseed hulls in the 7 days prior to fecal sample collection and feeding tallow in the 7 days prior to fecal sample collection were found to be associated with the detection of *Salmonella* in feedlot pens. The table below gives the odds ratios from the multivariable model.

Variable/ response	Odds Ratio	95% CI	*P*
Region			
Southern	3.329	0.629 to 17.611	0.161
Middle	2.931	0.894 to 9.608	0.079
Northern	1.000		
Cottonseed whole or hull fed last 7 d			
Yes	3.518	1.038 to 11.919	0.046
No	1.000		
Tallow fed last 7 d			
Yes	2.295	1.020 to 5.164	0.048
No	1.000		

Cottonseed products were fed more in the Southern region (where cotton is largely grown) than in the other regions,which may partly explain regional differences in *Salmonella* detection observed univariately. Immune function aberrations have been reported in cattle fed whole cottonseed (O'Kelly, 1984). In addition, molds capable of sythesizing mycotoxins (which can impair immune function) have been identified on cottonseed (Coppock et al., 1987). If feeding cottonseed is associated with impaired immune function, then one might expect to observe increased *Salmonella* shedding among cattle fed cottonseed. Furthermore, lint is usually not completely removed from cottonseed fed to cattle (Coppock et al., 1985), and may be attractive to rodents which have been identified as a potential source of *Salmonella* on farms (Pelzer, 1989).

Rendered products (such as tallow) may become contaminated with *Salmonella* (Pelzer, 1989). Although heated and cooked during processing (Lowry, 1993), they can be recontaminated after processing (Pelzer, 1989). Although *Salmonella* has limited tolerance for elevated temperatures, *Salmonella* suspended in fat with <10% moisture has greatly increased heat resistance (Lowry, 1993). Thus, feeds high in fat (such as tallow) may require higher temperatures and longer cooking time to kill all of the *Salmonella*.

4. Conclusions

The COFE provided information from feedlot operations representing 85.8% of the cattle inventory on feedlot operations in the United States. Baseline measurements relating to management practices such as quality assurance measures, branding and injection practices were collected and summarized. Factors associated with the detection of *Salmonella* were identified. With this information, those who influence decision-making in feedlots can make changes leading to better quality products and improved health.

5. References

Bean, N.H., and Griffin, P.M. 1990. Foodborne disease outbreaks in the United States, 1973-1987: pathogens, vehicles and trends. J. Food Prot. 53:804-817.

Cochran, W.G. 1977. Sampling Techniques, Third Edition. John Wiley and Sons, New York.

Coppock, C.E., Lanham, J.K., and Horner, J.I. 1987. A review of the nutritive value and utilization of whole cottonseed, cottonseed meal and associated by-products by dairy cattle. Anim. Feed Sci. Technol. 18:89-129.

Coppock, C.E., Moya, J.R., West, J.W., Nave, D.H, Labore, J.M., and Gates, C.E. 1985. Effect of lint on whole cottonseed passage and digestibility and diet choice on intake of whole cottonseed by Holstein cows. J. Dairy Sci. 68:1198-1206.

Chromy, J.R. 1981. Variance estimators for a sequential sample selection procedure. In D. Krewsky, R. Platek, and J.N.K. Rao (Eds.) Current Topics in Survey Sampling. Academic Press, Inc., New York, pp. 329-343.

Dargatz, D.A. 1994. Health practices in United States beef cow operations. Ph.D. Dissertation. Colorado State University, Fort Collins.

Dexter, D.R., Cowman, G.L., Morgan, J.B., Clayton, R.P., Tatum, J.D., Sofos, J.N., Schmidt, G.R., Glock, R.D., and Smith, G.C. 1994. Incidence of injection-site blemishes in beef top sirloin butts. J. Anim. Sci. 72:824-827.

Frye, W.B. 1995. Branding practices in the U.S. beef industry and their economic costs. M.S. Thesis. Colorado State University, Fort Collins.

Heinrichs, A.J., Wells, S.J., Hurd, H.S., Hill, G.W., and Dargatz, D.A. 1994. The national dairy heifer evaluation project: a profile of heifer management practices in the United States. J. Dairy Sci. 77:1548-1555.

Hueston, W.D. 1990. The national animal health monitoring system: addressing animal health information needs in the U.S.A. Prev. Vet. Med. 8:97-102.

Jones, R., Schroeder, T., Mintert, J. and Brazle, F. 1992. The impacts of quality on cash fed cattle prices. So. J. Ag. Econ. 24(2):149-162.

King, L.J. 1990. The national animal health monitoring system: fulfilling a commitment. Prev. Vet. Med. 8:89-95.

Leech, F.B. 1971. A critique of the methods and results of the British national surveys of disease in farm animals. II. Some general remarks on population surveys of farm animal disease. Br. Vet. J. 127:587-592.

Lowry, D. 1993. Effect of rendering on salmonella. In B. Spooncer and P. Husband (Eds.) Hygienic Production of Rendered Animal Products. McBenny Pty Ltd, Carina, Queensland, pp. 47-52.

Martin, S.W., Meek, A.H., and Willeberg, P. 1987. Veterinary Epidemiology Principles and Methods. Iowa State University Press, Ames, IA.

O'Kelly, J.C. 1984. Decreased resistance of *Bos taurus* cattle on a diet supplemented with whole cottonseed to the tick *Boophilus microplus (Canestrini)*. Vet. Parasitol. 15:151-157.

Research Triangle Institute. 1992. Professional Software for Survey Data Analysis, Release 6.0. SUDAAN User's Manual. Research Triangle Institute, Research Triangle Park, NC.

Pelzer, K.D. 1989. Salmonellosis. J. Am. Vet. Med. Assoc. 195:456-463.

SAS. 1990. SAS® Procedures Guide (Version 6 Ed.). SAS Institute Incorporated, Cary, NC.

USDA:APHIS:VS, National Animal Health Monitoring System. 1995. Cattle on feed evaluation, part I: feedlot management report. Fort Collins, CO: USDA. N172.1294.

Williams, G.W. 1980. Bovine salmonellosis. Bovine Pract. 15:122-128.