A Review of Morbidity and Mortality Rates and Disease Occurrence in North American Feedlot Cattle

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Abstract

A review of veterinary literature on morbidity or mortality rates in feedlot cattle was performed. Incidence (attack) rates were the only types of rates reviewed. Differences in the definition of terms made reports difficult to compare. Case-definitions were often poorly defined and most were based on chemotherapeutic treatment as a criterion. A summary was made of 14 comparable studies containing disease incidence rates in calves in the first few weeks following arrival in feedlots. The incidence of morbidity ranged from 0% to 69% with most reports between 15% and 45%. The mortality rate in the same period ranged from 0% to 15% with most reports between 1% and 5%. The peak incidence of disease was within the first three weeks after the arrival of calves in the feedlots. Few other epidemiological descriptions (season, day of the week, geographical, age, sex, or breed) had been objectively described. The most common clinical and necropsy diagnoses were respiratory infections, often described as shipping fever.

Key words: Morbidity rate, mortality rate, disease, feedlot, bovine.

Résumé

Une revue des taux de morbidité et de mortalité, ainsi que de l'incidence des maladies, chez les bovins des parcs d'engraissement, en Amérique du Nord.

Cette étude consistait à effectuer une revue de la littérature vétérinaire, relative aux taux de morbidité et de mortalité des bouvillons des parcs d'engraissement. Elle ne rapporte que les taux d'incidence, ou d'attaque. Des différences dans la définition des termes rendirent difficile toute comparaison entre les rapports. Les définitions de cas étaient souvent confuses et la chimiothérapie en constituait presque toujours le critère de base. Les auteurs résumèrent 14 études comparables qui contenaient le taux d'incidence des maladies, chez des veaux, au cours des premières semaines ultérieures à leur arrivée dans des parcs d'engraissement. Le taux de morbidité variait de 0% à 69%, mais, dans la plupart des rapports, il se situait entre 15% et 45%. Au cours de la même période, le taux de mortalité variait de 0% à 15%, mais, dans la plupart des rapports, il se situait entre 1% et 5%. L'incidence la plus élevée survint au cours des trois semaines ultérieures à l'arrivée des veaux dans les parcs d'engraissement. Seulement quelques autres paramètres épizootiologiques tels que la saison, le jour de la semaine, la région, l'âge, le sexe ou la race, faisaient l'objet d'une description objective. Des infections respiratoires, souvent décrites comme la fièvre du transport, correspondaient aux diagnostics cliniques et pathologiques les plus fréquents.

Mots clés: taux de morbidité, taux de mortalité, maladie, parc d'engraissement, bovins.

Introduction

Morbidity and mortality rates and their patterns are extremely important epidemiological statistics. As quantitative descriptions of disease levels and time of occurrence they give major insights into etiological and pathological processes. Many descriptive epidemiological studies have reported morbidity and mortality rates in North American feedlots. However, they are not well standardized and considerable variation occurs in the definition of rates.

In this review we have examined morbidity and mortality rates and other epidemiological parameters reported from recent literature on feedlot cattle in North America. Papers which contained data that allowed the calculation of morbidity or mortality incidence rates for feedlot cattle were examined. They spanned the period 1955-1984.

This review gives an outline of disease occurrence in the feedlot industry. The problems of morbidity and mortality rate definitions are discussed, and selected papers are used to examine the range of disease incidence rates in calves. Epidemic curves and other epidemiological descriptions are reviewed, and the common clinical and necropsy diagnoses are noted.

Disease Occurrence in the Industry

Feedlots are an integral part of North American beef production. Beef calves typically start their lives on breeding ranches and remain with their mothers for several months until, after weaning, they are transported to a feedlot and initiated into the more intensively managed husbandry system. Occasionally cattle do not enter feedlots until their second year (yearlings). In either case, a period of considerably increased disease occurrence is recognized soon after the arrival of cattle at the feedlots (1-7). The post-arrival disease peak consists largely of respiratory infections (2, 4, 5, 7-9). The peak occurs so reliably that feedlot managers usually observe calves closely during this time to allow early detection and treatment of clinical cases. Similarly, the studies examined in this review concentrated on the postarrival period.

Definition of Morbidity and Mortality Rates

All morbidity rates encountered in the review were incidence (or attack) rates. The simple method of calculating the incidence of morbidity in a group of animals is to count the animals which develop an illness (cases) over a period of time, and divide this number by the total number of animals in the group at the start of the time period. If the population-at-risk changes, an average may be used for the denominator (10-13). The result is the proportion of

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the group which fell ill, and its complement is the proportion which stayed healthy. The mortality incidence rate is similar, but only deaths are counted as cases.

Important variations may arise in the meaning of these terms when different case-definitions, time periods, and even denominator definitions are used. To enable meaningful summarization of the literature it was necessary to first examine these variations.

Variation in Definitions

The papers reviewed were of a variety of types. Many were experimental trials examining the effects of various treatments on health. Some were retrospective surveys, others were prospective observational studies, and some were studies of outbreaks or high-risk disease situations. All used morbidity or mortality statistics as a measure of animal health, and in many it was the major dependent variable. Table I summarizes, in chronological order, the location (state or province), the type of study (as defined above), and the type of cattle involved (calves or yearlings) in the 30 reports examined.

Case-definitions used for morbidity rates in these studies were often crudely defined, and most depended on an animal receiving chemotherapy as a criterion. In 15 of the reports (2, 5, 8, 9, 16, 18, 21-24, 31, 32, 34, 35, 37) "treatment" was used as a case-definition. For these, the morbidity rates calculated could be called "treatment rates". Eight papers (1, 3, 14, 26, 27, 29, 30, 36) simply stated "sickness" or "morbidity" as a case-definition. Five others (17, 19, 25, 28, 33) listed "respiratory disease" (some including a list of signs), and one study (15) used a high rectal temperature as the sole definition. The remaining paper (20) was concerned only with mortalities.

The time periods over which counts were made also varied. Twenty-seven of the studies commenced their observations with the arrival of a known group (cohort) of cattle in a feedlot, however, eight of these papers (2, 14, 19, 21, 23, 25, 31, 35) gave no indication of the duration for which they then counted cases! The time period of the 19 others varied from 11 days to "the whole feeding period", which is usually a span of several months. The denominator used in calculating rates for all these studies was the size of the group under observation.

In three studies (8, 20, 26) observations were made over a set period of calendar time (for example, January to December 1974). These works used a feedlot population turnover figure for the period of observation as a denominator. This is a valid technique, providing the observation period is long relative to the disease occurrence period under investigation. Since all three studies involved periods of at least eight months, this denominator probably approximates the approach used in the other reports.

TABLE I
References Containing Data on Morbidity or Mortality Rates in North American Feedlot Cattle

Ref. No.	Year of Publication	Location[a]	Type of Study[b]	Type of Cattle
14	1955	Ontario and Quebec	Trial	Calves
15	1957	Nebraska	Observational	Calves
16	1958	Montana	Outbreak	Calves
17	1958	Ohio	Trial	Calves
18	1961	Illinois	Outbreak	Calves
19	1967	Iowa	Outbreak	Calves
20	1967	Alberta	Observational	Unknown
21	1971	N. Dakota	Trial	Calves
22	1972	Alabama	Trial	Calves
1	1972	Colorado	Trial	Calves
2	1973	Illinois	Survey and trial	Calves
23	1973	Illinois	Trial	Calves
24	1974	N. Dakota	Trial	Calves
25	1974	Ontario	Trial	Yearlings
3	1975	California	Trial	Calves
26	1976	Colorado	Survey	Yearlings
27	1978	Texas	Trial	Calves
5	1978	California	Trial	Calves
28	1979	Texas	Trial	Calves
29	1980	New Mexico	Trial	Calves
8	1981	Alberta	Survey	Calves and yearlings
30	1981	Texas	Trial	Calves
9	1982	Ontario	Observational	Calves
31	1983	Alberta	Trial	Calves
32	1983	Ontario	Survey	Calves
33	1983	New Mexico	Trial	Calves
34	1983	Alberta	Observational	Yearlings
35	1983	Sask. and Ontario	Trial	Calves
36	1984	Texas	Trial	Calves
37	1984	Ontario and Quebec	Trial	Calves

[a]State(s) or province(s) where feedlots were located
[b]See text for description of categories

Morbidity and Mortality in Calves

In order to examine more closely the morbidity and mortality incidence rates experienced by calves in the immediate postarrival period, selected papers were used. All studies of calves, in nonoutbreak situations, were examined. Those which used a case-definition of "treatment", "sickness", or "respiratory disease", and which covered the first two to ten weeks postarrival, were selected.

To summarize each study, an overall morbidity or mortality incidence rate was calculated for all cattle, regardless of subdivisions into experimental groups if such were used. If the data allowed, the range of morbidity or mortality rates of any sub-groups involved was also calculated. Table II summarizes the 14 selected studies, in morbidity rate order, including summary morbidity and mortality incidence rates and ranges, the number of cattle and the number of sub-groups, the case definition, and the time period involved.

In the selected studies, summary morbidity incidence rates ranged from 8% to 56%, with sub-group rates ranging from 0% to 69%. Most reports were in the range 15% to 45%. Summary mortality incidence rates ranged from 0% to 5.6%, with sub-groups ranging from 0% to 15%. Most reports were between 1% and 5%.

Epidemic Curves

A graph showing the changes in morbidity or mortality rate with time is called an epidemic curve. It displays the dynamics of disease activity in a population and provides a basic epidemiological description (10-12, 38).

Literature on epidemic curves in feedlot cattle populations is rare. Martin

TABLE II
Summary Morbidity and Mortality Incidence Rates in Studies of Feedlot Calves in the Immediate Postarrival Period

Ref. No.	Summary[a] Morbidity Rate (%) (and range)	Summary[a] Mortality Rate (%) (and range)	No. of Calves	No. of Groups	Case-Definition Used	Postarrival Time Period (days)
24	8 (0-27)	0.2 (0-ND)	1167	20	Treatment	21
22	12 (0-21)	0 (0)	94	6	Treatment	28
1	17 (10-20)	1.8 (0-2.5)	1239	4	Sick	45
17	17 (4-29)	ND	782	ND	Treatment	42
9	29 (ND)	1.0 (ND)	52889	473	Treatment	Approx 62
37	30 (0-39)	3.3 (0-ND)	276	16	Trt. for BRD[b]	49
32	34 (ND)	1.5 (ND)	43065	ND	Treatment	31
36	37 (13-59)	5.6 (0-15.0)	267	12	Morbid	28
30	39 (21-53)	3.5 (1.0-8.9)	965	ND	Morbid	28
27	42 (35-58)	5.6 (2.3-13.8)	500	Approx 10	Sick	28
33	42 (6-69)	3.1 (0-11.9)	1185	96	BRD[b]	46
3	48 (36-62)	0.3 (0-2.6)	395	20	Sick	63
29	51 (40-62)	3.9 (2.4-5.0)	514	48	Sick	28
5	56 (55-58)	1.1 (0-2.5)	358	3	Treatment	28

[a]Summary rates are overall rates for all cattle in each study. Range is the range of rates in subgroups in the study, reported as (Min-Max)
[b]Bovine respiratory disease
ND = Not able to be determined

(7) published summary treatment-rate curves from the first five weeks post-arrival for a large number of groups of cattle, and Woods *et al* (2) and Andrews (39) showed epidemic curves for respiratory disease occurring over the first four weeks in small experimental groups. Other reports contained data which allowed extrapolation of rough epidemic curves for small groups (3, 15, 16, 34, 40). The conclusion drawn from all studies is that morbidity rates peak in feedlots in the first three weeks after cattle arrive. This is followed by a reduction to a lower rate, by four to five weeks, which is maintained through the rest of the feeding period.

Studies using mortality instead of morbidity for epidemic curves of feedlot groups, although sparse, show a similar pattern. Rothwell *et al* (6) published a mortality rate curve for the first 12 weeks postarrival showing a peak around two weeks after arrival and a drop to a lower level by week 4. Jensen *et al*, in the Colorado study (4, 41-46), described in outline terms the epidemic curves, throughout the period of feedlot residence, for seven different disease conditions (shipping fever, atypical interstitial pneumonia, bronchiectasis, brisket disease, embolic pulmonary aneurysms, fatal abomasal ulcers, and sudden deaths). Many of these conditions showed a fairly even distribution, but shipping fever, which accounted for the largest number of fatalities, was concentrated in the early postarrival period. Niilo *et al* (20) confirmed this pattern.

The common rise-and-fall pattern of both morbidity and mortality rates supports one simple conclusion. The regular occurrence of a disease peak soon after cattle arrive at a feedlot demonstrates the association between management and disease. Investigations into this link are widespread and have addressed most aspects of the process of transition of a calf from ranch-life to feedlot, including weaning, transport, mixing and processing (2, 9, 22, 30, 47-55).

Other Epidemiological Descriptions

Apart from the basic disease description parameters already discussed, there are a host of less commonly reported features which may be used to describe disease patterns. These include other temporal distributions of disease (season, day of the week), the geographical distribution, and the distribution by type of animal (sex, age, breed).

Seasonal patterns have been commented on by Jensen *et al* (26) who stated that morbidity and mortality rates were highest in fall, less in winter, and least in spring and summer. Patterns reported for respiratory conditions also point to peak occurrence in fall (4, 39, 56). However, it may be that the increased proportion of newly-arrived young calves at that time of year explains these findings, rather than a true seasonal effect since none of the studies controlled for this complication.

The distribution of disease by day of the week has not been described for feedlot cattle. Geographic patterns have not been reported either, although it would appear from the papers reviewed that, within North America, disease occurs wherever there are feedlots.

The types of animals affected by disease within feedlots are also poorly described. Breed and sex differences have not been well reported. Age is considered an important factor influencing disease levels (57, 58), with younger cattle more disease-prone than older. Age effects appear in the literature mainly by the distinction between "calves" and "yearlings" although these terms are not always mutually exclusive. Jensen and Mackay (59) commented that shipping fever morbidity for calves was about 25% compared to 3% to 4% for yearlings. Mortality rates were similarly related. Church (58) described a similar pattern in a review of disease levels reported for calves and yearlings but none of the studies in his summary compared the two age groups directly and no conclusion was drawn about the differences involved.

Clinical Diagnosis

A review of the clinical disease entities reported in feedlot cattle would resemble a textbook on cattle diseases. Recent literature on the subject, both objective and subjective, suggests that a small number of diseases dominate. A more complete review is available (59).

Respiratory diseases, particularly shipping fever, are clearly the most common. Jensen *et al* (4) reported that respiratory tract diseases accounted for 75% of illnesses in a large survey. A panel of American veterinarians (60) named the following disease entities most commonly reported as the causes of disease in feedlots: bacterial pneumonias, infectious bovine rhinotracheitis (IBR), other respiratory conditions, bovine virus diarrhea (BVD), parasitism, and clostridial diseases. In a review by Martin (7), pneumonia and IBR were again proposed as the most important diseases, and Church and Radostits in Alberta (8) found farmer diagnoses of shipping fever, IBR, and footrot to be the most common. Nonfatal diseases such as footrot and "bulling", which tend to lose the limelight to more lethal conditions, also had a significant frequency (7, 8, 61).

Necropsy Diagnoses

Necropsy surveys provide fairly objective information on fatal conditions which occur in feedlot cattle, although

pathological diagnoses still suffer at times from poor definition and from confusion in nomenclature.

Six main works have been reported in this area in recent times. In 1967 Niilo *et al* (20) published a necropsy survey of dead cattle from four southern Alberta feedlots. Jensen *et al* reported a series of results from a similar survey in Colorado in 1976 (4, 26, 41-46). More recently Rothwell *et al* described a single feedlot survey (6), Church and Radostits (8) reported on farmer diagnoses of cause of death from 24 Albertan feedlots, and Martin *et al* (9) gave results of a large observational study in Ontario. Finally, Hjerpe (62) described the respiratory conditions he found among 2,000 necropsies.

These studies are difficult to compare because of the variety of reporting styles, however, simple categorization into major body systems, as used by some authors (6, 8), allows rough summarization. In all papers the system most commonly named as the cause of death was the respiratory system. The percentage of deaths due to respiratory lesions varied from 31% (20) to 71% (8) and all authors stated that the principal lesion was pneumonia.

The second most commonly affected system in the four papers which reported full data (6, 8, 20, 26) was the alimentary tract. From 10% (6) to 22% (20) of fatal conditions involved this system, but the diagnoses were diverse. The nervous, musculoskeletal, urogenital, and cardiovascular systems each accounted for lower proportions ranging only as high as 11%.

Summary and Conclusions

The North American feedlot industry, like any intensive animal industry, suffers from disease problems. A major area of concern is the peak of disease incidence, due mostly to respiratory infections, which occurs in the period soon after calves arrive in the feedlot. Around 15% to 45% of incoming calves require treatment, and around 1% to 5% die.

Deficiencies exist in current knowledge of the basic epidemiological behavior of disease in feedlots. Morbidity and mortality rate calculations are ill-defined. The common use of crude case-definitions for morbidity counts such as "treated" or "sick" leaves scope for large differences between studies or even observers. Their use may introduce a large amount of subjectivity to the measurement of morbidity. The failure to clearly state a time period when quoting a rate is reprehensible. Epidemiological descriptions other than morbidity and mortality rates, such as epidemic curves, are largely undescribed.

Much clinical and pathological groundwork has been done to establish basic data on feedlot health problems. Laboratory investigations into the cause and prevention of the major diseases are common. However, to maintain a logical progression of research, more epidemiological information is necessary.

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References

1. KNIGHT AP, PIERSON RE, HOERLEIN AB, COLLIER JH, HORTON DP, PRUETT JB. Effect of vaccination time on morbidity, mortality, and weight gains of feeder calves. J Am Vet Med Assoc 1972; 161:45-48.
2. WOODS GT, MANSFIELD ME, WEBB RJ. A three year comparison of acute respiratory disease, shrink and weight gain in preconditioned and non-preconditioned Illinois beef calves sold at the same auction and mixed in a feedlot. Can J Comp Med 1973; 37:249-255.
3. LOFGREEN GP, DUNBAR, JR, ADDIS DG, CLARK JG. Energy level in starting rations for calves subjected to marketing and shipping stress. J Anim Sci 1975; 41:1256-1265.
4. JENSEN R, PIERSON, RE, BRADDY PM, SAARI DA, LAUERMAN LH, ENGLAND JJ, KEYVANFAR H, COLLIER JR, HORTON DP, McCHESNEY AE, BENITEZ A, CHRISTIE RM. Shipping fever pneumonia in yearling feedlot cattle. J Am Vet Med Assoc 1976; 169:500-506.
5. LOFGREEN GP, ADDIS DG, DUNBAR JR, CLARK JG. Time of processing calves subjected to marketing and shipping stress. J Anim Sci 1978; 47:1324-1328.
6. ROTHWELL BW, MILLS JH, DOIGE CE. Necropsies on feedlot cattle: Respiratory diseases. First Western Canadian Veterinary Conference, University of Saskatchewan, June 11-15, 1979.
7. MARTIN SW. Factors influencing morbidity and mortality in feedlot calves in Ontario. Vet Clin North Am (Large Anim Pract) 1983; 5:75-86.
8. CHURCH T, RADOSTITS OM. A retrospective survey of diseases of feedlot cattle in Alberta. Can Vet J 1981; 22:27-30.
9. MARTIN SW, MEEK AH, DAVIS DG, JOHNSON JA, CURTIS RA. Factors associated with mortality and treatment costs in feedlot calves: The Bruce County beef project, years 1978, 1979, 1980. Can J Comp Med 1982; 46:341-349.
10. ELLIOTT REW, TATTERSFIELD JG. Investigating animal disease status. Wellington, New Zealand: Animal Health Division, Ministry of Agriculture and Fisheries, 1979.
11. FRIEDMAN GD. Primer of epidemiology. 2nd ed. New York: McGraw-Hill, 1980.
12. LILIENFELD AM, LILIENFELD DE. Foundations of epidemiology. 2nd ed. New York: Oxford University Press, 1980.
13. BARKER DJP. Practical epidemiology. 3rd ed. Edinburgh: Churchill Livingstone, 1982.
14. MOYNIHAN WA. Survey of shipping fever in Canada: Objectives and organization of 1954 survey. Can J Comp Med 1955; 19: 327-328.
15. HOERLEIN AB, MARSH CL. Studies on the epizootiology of shipping fever in calves. J Am Vet Med Assoc 1957; 131:123-127.
16. PALOTAY JL, NEWHALL JH. Pneumonia in newly weaned calves — report of a field study. J Am Vet Med Assoc 1958; 133: 353-357.
17. KING NB, GALE C, SMITH HR, HAMDY AH, SANGER VL, POUNDEN WD, KLOSTERMAN EW. Stress factors in shipping fever. Vet Med 1958; 53:67-72.
18. HOERLEIN AB, SAXENA SP, MANSFIELD ME. Studies on shipping fever of cattle. II. Prevalence of pasteurella species in nasal secretions from normal calves and calves with shipping fever. Am J Vet Res 1961; 22:470-472.
19. BRISTOL RF. Preconditioning of feeder cattle prior to interstate shipment. J Am Vet Med Assoc 1967; 150:69-70.
20. NIILO L, DORWARD WJ, AVERY RJ. A note on an investigation of mortality in feedlot cattle. Can Vet J 1967; 8:101-103.
21. SCHIPPER IA, KELLING CL. Shipping fever prophylaxis: Comparison of vaccine and antibiotics administered following weaning. Can Vet J 1971; 12:172-175.
22. KIESEL GK, ROSSI CR, ALEXANDER HD, BROOKS GG. A study of weaning, acclimatization, and limited vaccination on the incidence of respiratory disease complex in cattle. Cornell Vet 1972; 62:454-463.
23. WOODS GT, PICKARD JR, COWSERT C. A three year field study of preconditioning native Illinois beef calves sold through a cooperative marketing association — 1969 to 1971. Can J Comp Med 1973; 37:224-227.
24. SCHIPPER IA, KELLING CL. Prophylactic use of antibiotics in preventing bovine respiratory disease complex. Vet Med Small Anim Clin 1974; 69:1396-1401.
25. CURTIS RA, ANGULO A. Field trial to evaluate an intranasal infectious bovine rhinotracheitis vaccine. Can Vet J 1974; 15:327-330.
26. JENSEN R, PIERSON RE, BRADDY PM, SAARI DA, LAUERMAN LH, ENGLAND JJ, HORTON DP, McCHESNEY AE. Diseases of yearling feedlot cattle in Colorado. J Am Vet Med Assoc 1976; 169:497-499.
27. COPE GE. For better health ship them full. Proc 11th Am Assoc Bovine Practnrs. December 11-14, 1978:116-117.
28. COLE NA, McLAREN JB, IRWIN MR. Influence of pre-transit feeding regime and post-transit B-vitamin supplementation on stressed feeder steers. J Anim Sci 1979; 49:310-317.
29. LOFGREEN GP, STINOCHER LH, KIESLING HE. Effects of dietary energy, free choice alfalfa hay and mass medication on calves subjected to marketing and shipping

stresses. J Anim Sci 1980; 50:590-596
30. CAMP TH, STEVENS DG, STERMER RA, ANTHONY JP. Transit factors affecting shrink, shipping fever and subsequent performance of feeder calves. J Anim Sci 1981; 52:1219-1224.
31. KARREN D, CHURCH T. Alberta certified preconditioned feeder program, 1983 annual report. Edmonton, Alberta: Alberta Dept Agriculture, 1984.
32. HUTCHINGS DL, MARTIN SW. A mail survey of factors associated with morbidity and mortality in feedlot calves in southwestern Ontario. Can J Comp Med 1983; 47:101-107.
33. LOFGREEN GP. Mass medication in reducing shipping fever-bovine respiratory disease complex in highly stressed calves. J Anim Sci 1983; 56:529-536.
34. YATES WDG, KINGSCOTE BF, BRADLEY JA, MITCHELL D. The relationship of serology and nasal microbiology to pulmonary lesions in feedlot cattle. Can J Comp Med 1983; 437:375-378.
35. MARTIN W, WILLSON P, CURTIS R, ALLEN B, ACRES S. A field trial, of preshipment vaccination, with intranasal infectious bovine rhinotracheitis-parainfluenza-3 vaccines. Can J Comp Med 1983; 47:245-249.
36. HUTCHESON DP, COLE NA, McLAREN JB. Effects of pre-transit diets and post-transit potassium levels for feeder calves. J Anim Sci 1984; 58:700-707.
37. MARTIN W, ACRES S, JANZEN E, WILSON P, ALLEN B. A field trial of preshipment vaccination of calves. Can Vet J 1984; 25:145-147.
38. SCHWABE CW, RIEMANN HP, FRANTI CE. Epidemiology in veterinary practice. Philadelphia: Lea & Febiger, 1977.
39. ANDREWS AH. Factors affecting the incidence of pneumonia in growing bulls. Vet Rec 1976; 98:146-149.
40. ZWEIACHER ER, DURHAM RM, BOREN BD, GASKINS CT. Effects of method and time of castration of feeder calves. J Anim Sci 1979; 49:5-9.
41. JENSEN R, PIERSON RE, BRADDY PM, SAARI DA, LAUERMAN LH, ENGLAND JJ, BENITEZ A, HORTON DP, McCHESNEY AE. Atypical interstitial pneumonia in yearling feedlot cattle. J Am Vet Med Assoc 1976; 169:507-510.
42. JENSEN R, PIERSON RE, BRADDY PM, SAARI DA, LAUERMAN LH, BENITEZ A, CHRISTIE RM, HORTON DP, McCHESNEY AE. Bronchiectasis in yearling feedlot cattle. J Am Vet Med Assoc 1976; 169:511-514.
43. JENSEN R, PIERSON RE, BRADDY PM, SAARI DA, BENITEZ A, HORTON DP, LAUERMAN LH, McCHESNEY AE, ALEXANDER AF, WILL DH. Brisket disease in yearling feedlot cattle. J Am Vet Med Assoc 1976; 169:515-517.
44. JENSEN R, PIERSON RE, BRADDY PM, SAARI DA, LAUERMAN LH, ENGLAND JJ, BENITEZ A, HORTON DP, McCHESNEY AE. Embolic pulmonary aneurysms in yearling feedlot cattle. J Am Vet Med Assoc 1976; 169:518-520.
45. JENSEN R, PIERSON RE, BRADDY PM, SAARI DA, BENITEZ A, LAUERMAN LH, HORTON DP, McCHESNEY AE. Fatal abomasal ulcers in yearling feedlot cattle. J Am Vet Med Assoc 1976; 169:524-526.
46. PIERSON RE, JENSEN R, LAUERMAN LH, SAARI DA, BRADDY PM, McCHESNEY AE, HORTON, DP. Sudden deaths in yearling feedlot cattle. J Am Vet Med Assoc 1976; 169:527-529.
47. THOMSON RG, GILKA F. A brief review of pulmonary clearance of bacterial aerosols emphasizing aspects of particular relevance to veterinary medicine. Can Vet J 1974; 15: 99-107.
48. CROOKSHANK HR, ELISSALDE MH, WHITE RG, CLANTON DC, SMALLEY HE. Effect of transportation and handling of calves upon blood serum composition. J Anim Sci 1979; 48:430-435.
49. IRWIN MR, McCONNELL S, COLEMAN JD, WILCOX GE. Bovine respiratory disease complex: A comparison of potential predisposing and etiologic factors in Australia and the United States. J Am Vet Med Assoc 1979; 175:1095-1099.
50. LANDI MS, KREIDER JW, LANG CM, BULLOCK LP. Effects of shipping on the immune function of mice. Am J Vet Res 1982; 43:1654-1657.
51. KENT JE, EWBANK R. The effect of road transportation on the blood constituents and behaviour of calves. I. Six months old. Br Vet J 1983; 139:228-235.
52. WILSON S. The epidemiology of respiratory disease in feedlot cattle in Alberta. Can Vet J 1984; 25:43-44.
53. PHILLIPS WA. The effect of assembly and transit stressors on plasma fibrinogen concentration of beef calves. Can J Comp Med 1984; 48:35-41.
54. FILION LG, WILLSON PJ, BIELEFELDT-OHMANN H, BABIUK LA, THOMSON RG. The possible role of stress in the induction of pneumonic pasteurellosis. Can J Comp Med 1984; 48:268-274.
55. KELLEY KW. Immune responses and plasma hormone concentrations in cold-exposed, xeranol-implanted calves. Am J Vet Res 1984; 45:2617-2621.
56. WEBSTER AJF. Environmental and physiological interactions influencing resistance to infectious disease. In: Dunlop RH, Moon HW, eds. Resistance to infectious disease. Saskatoon: Saskatoon Modern Press, 1970.
57. O'MARY CC. Types of cattle to feed. In: Dyer IA, O'Mary CC, eds. The feedlot. Philadelphia: Lea & Febiger, 1972: 83-99.
58. CHURCH TL. Preventive medicine in the feedlot. Vet Clin North Am (Large Anim Pract) 1983; 5:29-39.
59. JENSEN R, MACKEY DR. Diseases of feedlot cattle. 3rd ed. Philadelphia: Lea & Febiger, 1979.
60. PANEL REPORT. Diseases in feeder calves. Mod Vet Pract 1974; 55:413-417.
61. PIERSON RE, JENSEN R, BRADDY PM, HORTON DP, CHRISTIE RM. Bulling among yearling feedlot steers. J Am Vet Med Assoc 1976; 169:521-523.
62. HJERPE CA. Clinical management of respiratory disease in feedlot cattle. Vet Clin North Am (Large Anim Pract) 1983; 5:119-142.