Factors Associated with Morbidity and Mortality in Feedlot Calves: The Bruce County Beef Project, Year Two

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ABSTRACT

The results of the second year of the project confirmed most of the major findings from the initial year. Feeding cornsilage, particularly as the major roughage in the first month after arrival was associated with excess mortality. Mixing of cattle from different sources and vaccinating against respiratory disease appeared to be the most important additional factors that increased mortality rates. Delaying vaccination at least two days postarrival may have prevented the negative effects of vaccination but only in calves fed cornsilage.

Morbidity rates were highly variable among farms but were positively correlated with mortality rates and treatment costs. The occurrence of infectious thromboembolic meningoencephalitis appeared to share some of the same risk factors as mortality; whereas, urolithiasis did not. Water deprivation may be a risk factor in the occurrence of urolithiasis.

Fibrinous pneumonia was again the most frequent cause of death. Relative to year one, infectious thromboembolic meningoencephalitis increased in frequency and only one death was attributed to bovine virus diarrhea.

RÉSUMÉ

Les résultats obtenus au cours de la deuxième année de ce projet confirmèrent la plupart des observations enregistrées l'année précédente. Le fait de donner de l'ensilage de maïs, surtout à titre de principal aliment grossier, au cours du mois qui suivit l'arrivée des veaux dans les parcs d'engraissement, se traduisit par un taux plus élevé de mortalité. Le regroupement de sujets issus de plusieurs fermes et la vaccination contre les maladies respiratoires, semblèrent représenter les facteurs additionnels les plus importants qui augmentèrent le taux de mortalité. Le fait de retarder la vaccination des veaux d'au moins deux jours après leur arrivée dans les parcs d'engraissement, pourrait avoir prévenu les effets négatifs de la vaccination, mais seulement chez les veaux nourris à l'ensilage de maïs.

Le taux de morbidité s'avéra très variable, d'un parc d'engraissement à l'autre; il se révéla toutefois en relation directe avec le taux de mortalité et le coût des traitements. L'incidence de la méningo-encéphalite thromboembolique sembla partager certains des facteurs prédisposants de la mortalité, contrairement à l'urolithiase.

La pneumonie fibrineuse se révéla encore la cause la plus fréquente de mortalité. La méningo-encéphalite thromboembolique s'avéra plus fréquente qu'au cours de l'année précédente tandis que la diarrhée à virus bovine ne causa qu'une mortalité.

INTRODUCTION

Sickness and death in young beef calves following introduction into the feedlot are major problems for the feedlot manager. The "shipping-fever-complex" is the most frequently occurring syndrome and cause of death and epidemiological studies were initiated, in Bruce County, in 1978 to identify those factors associated with morbidity and mortality (6). This study involved approximately 70 feedlot owners who kept daily records of animals treated, deaths and health related expenses, during the first five weeks after arrival of the feeder calves. A detailed survey of the housing, feeding and management of the calves was performed. Most dead calves were examined by pathologists at the Ontario Veterinary College and the pathologist's report was returned, by phone, to the feedlot owner's veterinarian within 24 hours.

Although the results of the first year of the study were returned to and discussed with the collaborating farmers, no specific recommendations were given. The intent of the second year of the study was to validate the first year's findings and this paper provides the results of this investigation.

MATERIALS AND METHODS

The second year of the project was conducted in the same locale and in a manner similar to that previously described for year one (6). A meeting was held with the 98

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volunteer farmers in October 1979 to discuss the project and a decision was made that groups of calves arriving on or before December 7, 1979 would be eligible for the study.

Each farmer with cattle enrolled in the study was visited at least twice during the study period, once as soon as possible after each group of cattle arrived and the second time approximately three to four weeks later. During the initial visit, data concerning the characteristics of the animals in each group, their method of transportaion, their housing and management as well as prophylactic procedures (processing) used were collected. The second visit was used primarily to discuss project related problems with the farmer and to verify or complete data collection. The definition and coding of variables reported in this paper are shown in Table I.

Each farmer recorded in a daily log, the number of cattle per group and the number of calves that were treated (or died) each day. The format of the daily log was similar to a calendar with a box for each day allowing one months data to be recorded per sheet. Those who tagged their calves were requested to record the tag numbers of animals treated each day. Separate sheets to record these data were provided. These data plus all health related expenses were maintained from the date of arrival of the cattle group up to and including January 18, 1980. Data on numbers of cattle sold, date of selling and weight will be collected by the authors during the summer and fall of 1980, and will be reported later.

The unit of concern for the study was the smallest group of identifiable cattle possessing similar characteristics with respect to source, method and dates of transportation, housing, feeding and management. Calves in groups defined as "lots" had to arrive on the premises within 24 hours of each other, come from the same general locale (source) and be transported by the same means (truck or train). If calves in "lots"

TABLE I. The Definition and Coding of Variables used in a Study of Factors Associated with Morbidity, Mortality and Health Costs in Feedlot Calves

Variable	Definition/Codes/Comments
LOT	Does this group of cattle constitute a "lot"? /Yes=1, No=0
ARRIVED	Day of arrival referenced to day 0 at October 15
PURELINE	Is there one predominant breed present in this group? /Yes=1, No=0
NUMSEX	The number of sexes present in the group
EASTCAT	Are Ontario calves in this group? /Yes=1, No=0
PURCWEST	Were the cattle purchased west of Ontario? /Yes=1, No=0
WEIGHT	The average weight in lbs
PASTURE	Will these cattle be pastured in 1980? /Yes=1, No=0
FINISH	Will you "finish" these cattle for slaughter? /Yes=1, No=0
GOAL	Will you grow or fatten these cattle this winter? /Grow=1, Fatten=0
LIVE	The number of live calves in the group on arrival
TAG	Do you tag all treated cattle? /Yes=1, No=0
SEGREGAT	Do you segregate all treated cattle (=1); only the very sick cattle (=2); or none of the sick cattle (=3)
OFF-FARM	Do you have employment other than farming? /Yes=1, No=0
ANYHELP	Is hired help used to feed or treat the cattle? /Full-time=1, Part-time=2, None=3
CORNSIL	Was cornsilage fed as the major roughage during any of the first four weeks after arrival? /Yes=1, No=0
CORNRUF	Was cornsilage fed during any of the first four weeks after arrival? /Yes=1, No=0
HAYSIL	As per CORNSIL
HAYRUF	As per CORNRUF
HAYCEASE	How long was dry hay fed postarrival? /0-No hay fed 1-Hay fed 1 week 2-Hay fed $>1 \leq 2$ weeks 3-Hay fed $>2<3$ weeks 4-Hay fed $>3<4$ weeks 5-Hay fed >4 weeks 6-Only hay fed in first month
ROUGHAGE	Are the cattle kept hungry (0); fed what they will clean up (1); or fed free choice roughage (2), during the first two weeks after arrival?
LIMITAMT	After "settling-in" are the cattle fed roughage free choice? /Yes=1, No=0
COMPRATN	Is the roughage and concentrate fed as a mixed complete ration? /Yes=1, No=0
MIXGRAIN	Were oats or barley fed? /Yes=1, No=0
CORNGRAN	Was grain corn fed? /Yes=1, No=0
PROTSUPP	Was a protein supplement fed? /Yes=1, No=0
NONPROT	Was nonprotein nitrogen fed? /Yes=1, No=0
SALT	Was salt fed within three weeks after arrival? /Yes=1, No=0
MINERAL	Was mineral fed within three weeks after arrival? /Yes=1, No=0
FREE	Did the cattle have free access to pasture after arrival? /Yes=1, No=0
MIXED	Is there more than one group of cattle in the same (physical) pen? /Yes=1, No=0
ANTIBIOT	Was the entire group of cattle given injectable antimicrobials? /Yes=1, No=0
IMWORADE	Were the cattle implanted or dewormed or given vitamin *ADE* injections? /Yes=1, No=0
RESPVAC	Were the cattle vaccinated against respiratory disease? /Yes=1, No=0
HAEMOPH	Was a vaccine for *H. somnus* given? /Yes=1, No=0
IMPLANTED	Were the cattle implanted with growth promotants? /Yes=1, No=0
INTPARA	Was an anthelmintic used? /Yes=1, No=0
EXTPARA	Were the cattle treated for external parasites? /Yes=1, No=0
CASTRATE	Were more than 30% of the calves castrated after arrival? /Yes=1, No=0
DEHORN	Were more than 30% of the calves dehorned after arrival? /Yes=1, No=0
STARTER	Was a commercial starter ration fed? /Yes=1, No=0
ANTISTAR	Did the starter ration contain antimicrobials? /Yes=1, No=0
ANTIWATR	Were antimicrobials given via water? /Yes=1, No=0
TREAT$PH	Total treatment cost per head
PREV$PH	Total prophylactic-vaccine, antibiotics, anthelmintic — costs per head
MORTALITY%	Mortality rate as a percent
MORBIDITY%	Morbidity rate as a percent
RATION	The cattle were fed hay only (1), hay and silage mixture (2), or primarily cornsilage (3) in the first month after arrival

were mixed with other animals within three weeks of arrival, this was recorded. Calves in groups classified as "pens" usually contained cattle from more than one source, or cattle transported by different methods or cattle arriving in groups two or more days apart. The number of lots and pens formed the denominator for all tests of significance.

Data for the independent variables relating to management, ration and prophylactic procedures and operations were available for all calf groups. Data for variables relating to source, transportation and cattle characteristics were available only for calves in lots. Data relating to housing factors were available for all cattle not pastured on arrival and not moved within three weeks of arrival. Information on housing factors for calves moved later than three weeks postarrival pertained to the barn of initial location.

In general, three methods of analyses were used; cross tabulation procedures, discriminant analysis and odds-ratio techniques (2, 8). For this purpose, each cattle group was classified as a low or high mortality group depending on whether its mortality rate was below or above the median mortality rate.

Initially, three series of discriminant analyses were performed to identify variables of importance. In series one, the first variable selected, by the statistical algorithm, was CORNSIL. The variables PASTURE, FINISH and GOAL were then deleted and a second "run" performed. Thereafter, the variable selected second in each run, was deleted and another "run" performed. This was repeated until no variables selected second added significant information, at or below the 5% level, to the discriminant function. In series two, the variable CORNSIL was deleted and SEGREGAT was selected first by the discriminant program. No further runs were performed in series two. In series three, SEGREGAT was deleted and HAYCEASE was selected first by the discriminant program. Thereafter, a series of runs was performed by deleting the variable entering the discriminant function second, until no variables remained that added significant information to the function.

The final summary of the results was prepared in tabular and graphical form.

RESULTS

Sixty-nine of the 98 volunteer farmers received cattle prior to the deadline for inclusion and collaborated in the study. Fifty-eight of these farmers collaborated in the first year of the project. The number of cattle groups, morbidity, mortality and health related expenses are summarized in Table II. All correlation coefficients between treatment costs, preventive costs, morbidity and mortality rates were positive (Table III). Most deaths were attributed to pneumonias, particularly fibrinous pneumonia, but a significant number were attributed to infectious thromboembolic meningoencephalitis (ITEME) (Table IV).

The mortality rates classified according to "processing factors" and the roughage fed are shown in Table V. No significance tests were applied to these data; but, most comparisons would be nonsignificant statistically because of the small numbers of groups in many of the categories. However, mortality rates appeared lower in nonprocessed than processed calves (0.55% versus 0.61% and 0.72% versus 0.94% in hay and silage-fed groups respectively). There appeared to be a reduction in mortality rates by delaying processing in silage fed but not hay fed cattle and overall, silage-fed cattle appeared to have a higher mortality rate than hay-fed cattle.

Eight groups of cattle on the study came from eastern Ontario or Quebec. The average mortality rate for these latter groups was 2.2% in comparison to 0.68% for groups from other parts of Ontario. Because of this, these groups

TABLE II. A Summary of Morbidity and Mortality Rates and Health-related Expenses for Feeder Calves in the Bruce County Beef Project, 1979-80

No. Farms in study	69
No. Cattle Groups	133[a]
No. Cattle	19,400
No. Deaths	191
% Mortality	1%
% Morbidity	28%
No. treatments per sick animal	4
Cost per head: prevention	$0.94 ± 0.71
Cost per head: treatment	$2.92 ± 2.61

[a]Initially, 140 groups were included in the study but seven of these were deleted because they had fewer than 30 cattle per group

TABLE III. Correlation Coefficients Between Health Costs Per Head and Mortality and Morbidity Rates in Feedlot Calves. Data from Bruce County Beef Project, 1979-80

	TREAT$PH	PREV$PH	MORTALITY %	MORBIDITY %
TREAT$PH	1.00			
PREV$PH	0.32[s]	1.00		
MORTALITY %	0.45[as]	0.20[s]	1.00	
MORBIDITY %	0.69[bs]	0.12[ns]	0.36[s]	1.00

[a]On two farms, costs for treatment were allocated to cattle groups based on mortality
[b]On many farms, with two or more groups of cattle, costs for treatment were allocated to cattle groups based on morbidity
[s]significant at $p \leq 0.05$. ns = not significant at $p \leq 0.05$

TABLE IV. The Five Most Frequent Diagnoses in 167 Feedlot Calves Submitted to OVC for Postmortem Examination. Data from Bruce County Beef Project, 1979-80

Diagnosis[a]	Frequency	Percent of total
Fibrinous pneumonia	74	45
Broncho pneumonia	22	13
Interstitial pneumonia	9	5
Infectious bovine rhinotracheitis	5	3
Infectious thromboembolic meningoencephalitis	23	14

[a]Diagnosis considered to be the immediate cause of death. The cause of death in the remaining animals submitted for postmortem was attributed to other causes

TABLE V. Mortality Rate (%) in Feedlot Calves Classified According to Processing Factor and Ration. Data from Bruce County Beef Project, 1979-80

	Roughage					
	Hay-Fed groups			Silage-fed groups		
	Time of Processing (Postarrival)					
"Processing" Factor	< 2 days	> 2 days	Not done	< 2 days	> 2 days	Not done
IBR/PI_3/PAST[a]	0.61(3)[b]	2.75(3)	0.54(57)	1.92(3)	0.67(2)	0.72(65)
IBR/PI_3:NASAL[a]	0.37(3)	1.79(2)	0.60(58)	1.22(3)	0.95(3)	0.73(65)
IBR:NASAL[a]	0.92(4)	0.98(1)	0.58(58)	1.18(2)	—	0.75(68)
IBR: MUSC[a]	0.49(2)	0.45(7)	0.64(54)	1.04(10)	0.85(1)	0.69(53)
HAEMOPH	0.75(4)	2.75(3)	0.53(56)	0.92(3)	—	0.75(67)
IMPLANTED	0.84(7)	1.00(11)	0.49(45)	0.90(9)	0.73(32)	0.75(29)
INTPARA	0.67(10)	0.79(25)	0.44(28)	0.90(9)	0.93(14)	0.69(43)
EXTPARA	0.39(13)	0.73(39)	0.48(11)	0.76(26)	0.92(36)	0.00(3)
Average Mortality Rate (%)	0.61	0.92	0.55	0.94	0.85	0.72

[a]These vaccines were later pooled into one factor called RESPVAC — see Table I
[b]Number of cattle groups in brackets

were excluded from all further analyses.

The values of variables, relating factors of management, ration and prophylactic procedures and operations to level of mortality are shown in Table VI. The following variables occurred significantly more frequently (at or below the 0.05 probability level) in groups of cattle with low mortality rates: having only one sex of calf per group, planning to pasture the calves in the summer of 1980, planning to grow the animals during the winter of 1979-80 and not finishing the calves, not tagging or segregating treated calves, having employment other than farming, not feeding cornsilage as part of or as the major roughage, feeding hay throughout the first month after arrival, feeding mixed grains, not feeding grain corn or nonprotein nitrogen, not mixing cattle groups, not implanting, deworming or giving vitamins ADE, and not vaccinating against respiratory diseases.

The factor having the strongest association with mortality was CORNSIL (Table VII). Many of the above factors, except for RESPVAC, retained an association with mortality after the effects of CORNSIL were controlled statistically. Purchasing Ontario cattle was associated with low mortality; whereas feeding mineral supplements and dehorning calves were associated with high mortality. MIXED was selected as being an important var-

TABLE VI. The Values of Variables, According to Level of Mortality, in a Study of Mortality in Feedlot Calves. Data from the Bruce County Beef Project, 1979-80

Management and Demographic Variables[a]	Low Mortality Rate Groups	High Mortality Rate Groups[b]	Difference significant at or below[c]
LOT	0.56	0.43	0.13
ARRIVED	38.73	38.18	
PURELINE	0.72	0.59	0.13
NUMSEX	1.06	1.18	0.04
EASTCAT	0.14	0.08	
PURCWEST	0.81	0.80	
WEIGHT	440.06	440.41	
PASTURE	0.86	0.41	0.01
FINISH	0.41	0.67	0.02
GOAL	0.89	0.62	0.01
LIVE	131.70	149.59	
TAG	0.44	0.62	0.04
SEGREGAT	2.03	1.57	0.01
OFF-FARM	0.23	0.03	0.01
ANYHELP	2.38	2.11	0.14
CORNSIL	0.14	0.49	0.00
CORNRUF	0.34	0.56	0.02
HAYSIL	0.13	0.10	
HAYRUF	0.14	0.15	
HAYCEASE	5.25	4.57	0.00
ROUGHAGE	0.63	0.84	0.06
LIMITAMT	0.19	0.33	0.07
COMPRATN	0.25	0.46	0.01
MIXGRAIN	0.56	0.33	0.01
CORNGRAN	0.22	0.41	0.02
PROTSUPP	0.64	0.74	0.25
NONPROT	0.11	0.28	0.02
SALT	0.82	0.90	0.23
MINERAL	0.67	0.77	0.22
FREE	0.09	0.10	
MIXED	0.45	0.67	0.01
ANTIBIOT	0.02	0.07	0.16
IMWORADE	0.72	0.87	0.04
RESPVAC	0.30	0.49	0.03
HAEMOPH	0.05	0.11	0.16
EXTPARA	0.84	0.93	0.11
CASTRATE	0.45	0.48	
DEHORN	0.42	0.56	0.13
STARTER	0.06	0.05	
ANTISTAR	0.02	0.02	
ANTIWATR	0.03	0.07	

[a]See Table I for definition and codes
[b]High mortality groups were those having mortality rates of equal to or greater than 0.49%. The average mortality rate for the high mortality rate groups was 1.63% ± 0.42 and 0.03% ± 0.09 for the low mortality rate groups
[c]Only significance levels of 0.25 or less are provided

TABLE VII. Variables Selected[a], and their Standardized Discriminant Function Coefficients, in a Study of Mortality in Feedlot Calves. Data from Bruce County Beef Project, 1979-80

Entry Sequence	Series 1 Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7
1	CORNSIL/+0.8	CORNSIL/+0.7	CORNSIL/+0.9	CORNSIL/+1.1	CORNSIL/+1.0	CORNSIL/+1.1	CORNSIL/+0.7
2	PASTURE/-0.4	SEGREGAT/-0.4	NUMSEX/+0.5	OFF-FARM/NA	CORNGRAN/NA	DEHORN/+0.6	
3	NUMSEX/-0.4	OFF-FARM/NA	EASTCAT/-0.7		ANTIBIOT/+0.3	MINERAL/+0.3	
4	EASTCAT/-0.7	MINERAL/+0.5	DEHORN/+0.6		CORNRUF/-0.4	ANTIBIOT/+0.3	
5	SEGREGAT/-0.3	EASTCAT/-0.8	ANTIBIOT/+0.3		DEHORN/+0.6	MIXED/+0.5	
6	MIXED/+0.4	MIXED/+0.4	MIXED/+0.4		MIXED/+0.4	CORNRUF/-0.5	
Percentage of groups correctly classified	76.8%	75.2%	75.2%	74.4%	74.4%	76.0%	75.2%

[a]Only variables adding significant information (at or below the 5% level of significance) or a maximum of six variables per "run" are shown. The variable CORNSIL by itself provided information sufficient to classify 68% of the cattle groups correctly, with respect to mortality
NA-Variable withdrawn by the statistical algorithm from the function during the run

TABLE VIII. Variables Selected[a], and their Standardized Discriminant Function Coefficients, in a Study of Mortality in Feedlot Calves. Variable CORNSIL Deleted. Data from Bruce County Beef Project, 1979-80

Entry Sequence	Series 3 Run 1	Run 2	Run 3	Run 4	Run 5
1	HAYCEASE/-0.8	HAYCEASE/-0.4	HAYCEASE/-0.6	HAYCEASE/-0.6	HAYCEASE/-0.7
2	NUMSEX/+0.7	RESPVAC/+0.3	MIXED/+0.5	NONPROT/+0.3	
3	RESPVAC/+0.3	MIXED/+0.5		DEHORN/+0.6	
4		OFF-FARM/-0.3			
Percentage of groups correctly Classified	71.2%	67.2%	68.8%	68.8%	71.2%

[a]See footnotes in Table VII
The variable HAYCEASE by itself provided information sufficient to classify 58% of the cattle groups correctly, with respect to mortality

iable in five of the seven runs in series 1.

When CORNSIL was deleted — series 2 — SEGREGAT was the most important variable followed by MIXGRAIN, OFF-FARM and MIXED with standardized discriminant function coefficients (SDFCs) of -0.5, NA, -0.3 and +0.4 respectively (NA indicates that the SDFCs was not available because the factor was deleted, by the program, during the run). This run classified 73.6% of the cattle groups correctly.

When SEGREGAT was deleted — series 3 — the most important variable was HAYCEASE (Table VIII). The variables NUMSEX, RESPVAC, MIXED, OFF-FARM, NONPROT and DEHORN were significantly associated with mortality when the effects of HAYCEASE — feeding hay — were controlled statistically.

A new variable RATION was formed to replace variables describing the roughage content of the ration— see Table I for definition. This variable was selected first in subsequent analyses by the discriminant program (Table IX). NUMSEX, EASTCAT, OFF-FARM, RESPVAC and MIXED were significantly associated with mortality when the effects of RATION were controlled statistically.

The association between the feeding of corn silage and mortality is presented in Table X. In general, the rates of mortality, and the odds ratios, were higher when corn silage was present as the major roughage but the feeding of corn silage in any amount, also produced a significant increase in mortality (average odds ratios of 3.22 and 1.96 respectively).

The average values of selected variables for groups of cattle fed a majority of their roughage as corn silage are shown in Table XI. Factors that may explain the low mortality in groups fed a majority of their roughage as corn silage at two weeks postarrival appear to be MIXED and RESPVAC both of which were less frequent in this

TABLE IX. Variables Selected[a], and their Standardized Discriminant Function Coefficients, in a Study df Mortality in Feedlot Calves. Variable RATION Included. Data from Bruce County Beef Project, 1979-80

Entry Sequence	Run 1	Run 2	Run 3
1	RATION/+0.7	RATION/+0.7	RATION/+0.8
2	NUMSEX/+0.5	OFF-FARM/-0.3	RESPVAC/+0.3
3	EASTCAT/-0.7	RESPVAC/+0.3	
4		MIXED/+0.4	
Percentage of groups correctly classified	71.2%	69.6%	72.0%

[a]See footnotes in Table VII
The variable RATION by itself provided information sufficient to classify 68% of the cattle groups correctly, with respect to mortality

TABLE X. The Association between Cornsilage-based Rations and Mortality Rate in Feedlot Calves. Data from Bruce County Beef Project, 1979-80

Time (T) Postarrival in days	Cornsilage was major roughage at time T		Cornsilage was in the ration at time T	
0	3.20[a]	4.19%[b]	2.42[a]	1.16%[b]
7	2.98[a]	1.23%[b]	1.14[a]	0.59%[b]
14	1.50[a]	0.55%[b]	2.46[a]	0.75%[b]
28	22.20[a]	1.34%[b]	1.83[a]	0.74%[b]
Average odds-ratio[a]	3.22		1.96	
Chi-square association	8.76		5.35	

[a]Odds-ratios; these measure the change in risk of mortality between the factor being present versus absent at each time interval. The median mortality rate was 0.498%
[b]Mortality rates derived from mean of $\log_{10}$ transformed mortality rates

group of cattle. In addition, a study of the daily records revealed that many of the 17 groups feeding corn silage as the major roughage at week 4 had been experiencing morbidity and mortality concomitantly with the change in ration.

The relationship between roughage, having mixed cattle groups and using respiratory vaccines is summarized in Table XII. Within each roughage category, the unvaccinated nonmixed cattle groups had the lowest mortality and the mixed groups with vaccinated calves had the highest mortality. These associations are further summarized in Fig. 1.

Housing factors did not have a strong association with mortality. There was a higher mortality rate in those cattle groups moved from one barn to another in the first few months after arrival and in groups housed in barns containing permanent sick pens. Summary statistics relating to housing factors are presented in Table XIII.

There was no statistically significant difference in mortality rates between cattle transported by truck versus train; however, truck shipped cattle tended to have a lower rate (Table XIV). Although the differences were not significant, there was a tendency for cattle arriving in good to excellent condition to have lower mortality rates than those arriving in poor condition. There was no significant association between method of transportation and condition on arrival.

The number of animals with urolithiasis was found to be significantly lower in cattle arriving earlier during the fall period and significantly higher in western than Ontario calves. The occurrence of urolithiasis was not associated significantly ($p \leqslant 0.05$) with other factors. Urolithiasis tended to occur less frequently in truck-shipped than in train-shipped cattle ($\chi^2 = 2.39$) and tended to occur more frequently in groups with a relatively limited surface area of water available in the first few weeks postarrival. The mean surface area per head in those groups with no cases was 0.12 ft² in contrast to 0.05 ft² for those groups

TABLE XII. Summary Association Between Roughage Fed, MIXED, RESPVAC and Percent Mortality in Feedlot Calves. Data from Bruce County Beef Project, 1979-80

Roughage	MIXED	RESPVAC	%Mortality%	Number of groups
Corn silage	+	+	1.21	14
major	+	—	1.10	14
roughage	—	+	0.87	6
	—	—	0.67	5
Average[a]			0.96	
Silage fed	+	+	1.17	3
but corn	+	—	0.40	14
silage not	—	+	0.49	4
major roughage	—	—	0.06	9
Average[a]			0.53	
No silage	+	+	0.77	11
fed. Hay	+	—	0.51	14
is major	—	+	0.38	11
roughage	—	—	0.38	20
Average[a]			0.51	

[a]Arithmetic average of % mortality ignoring "number of groups"

TABLE XI. The Average Value of Factors: MIXING, HAYCEASE, IMWORADE, RESPVAC, EXTPARA, MIXGRAIN, CORNGRAN, PROTSUPP and MORTALITY in Cattle Fed Cornsilage as the Major Roughage. Data from Bruce County Beef Project, 1979-80

Time Postarrival when Cornsilage became Major Roughage (wks)	MIXED	HAYCEASE	IMWORADE	RESPVAC	EXTPARA	MIXGRAIN	CORNGRAN	PROTSUPP	MORTALITY%[a]	Numbers of Groups
0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	4.2	1
1	0.9	4.1	0.8	0.8	1.0	0.0	0.0	0.9	1.2	8
2	0.5	3.9	0.8	0.3	1.0	0.2	0.5	0.9	0.6	13
4	0.8	4.2	1.0	0.6	1.0	0.4	0.5	0.8	1.3	17

[a]Mean rates derived from $\log_{10}$ transformed rates

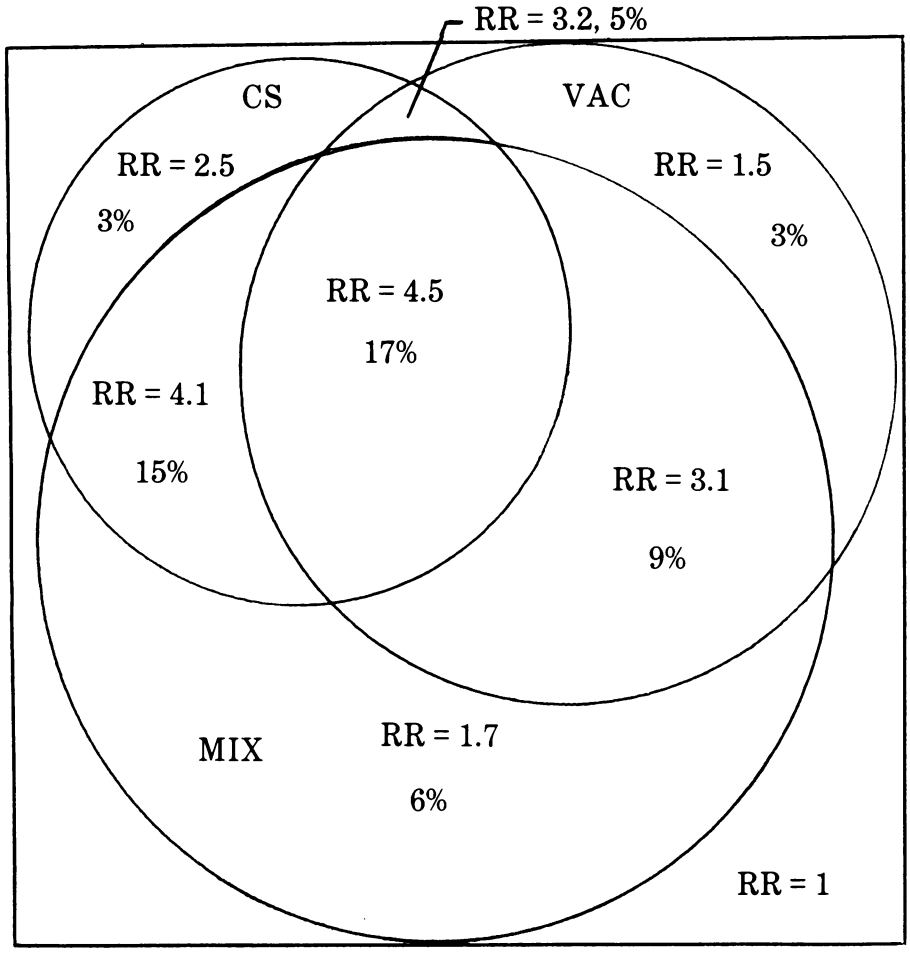

Fig. 1. The association between number and type of factor and the risk of excess mortality in feedlot calves. Data from Bruce County Beef Project 1979-80.
CS = CORNSIL VAC = RESPVAC MIX = MIXED
The area of the circles represents the proportion of calf groups experiencing that factor.
RR = Risk of mortality relative to the dry-hay-fed, nonvaccinated, nonmixed feedlot calves. The percentage of deaths attributable to each factor grouping is shown. In all, approximately 57% of all deaths were attributable to these three factors.

TABLE XIII. Descriptive Statistics for Housing Factors for Feedlot Calves. Data from the Bruce County Beef Project, 1979-80

Number of water sources per group	1.6 ± 0.8 (Mean ± Std. Dev.)
Proportion of groups provided with additional water sources on arrival	0.31 ± 0.46
Manger space per head (ft)	1.4 ± 0.6
Lounge space per head (within the barn) (ft²)	26.4 ± 13.2
Surface area of water per head (ft²)	0.11 ± 0.23

TABLE XIV. The Association Between Method of Transport, Condition on Arrival and Mortality Rate in Feedlot Calves

Cattle Shipped by	Mortality rate	Number of Groups
Truck	0.43%	33
Train	0.62%	31
Condition[a] of cattle on arrival		
Excellent	0.15%	10
Good	0.56%	49
Poor	1.00%	5

[a]Farmers subjective assessments

with one or more cases (p = 0.115).

The number of animals diagnosed with clinical ITEME was found to be significantly and positively associated with NONPROT and COMPRATN and negatively associated with *H. somnus* vaccine[1] use. Infectious thromboembolic meningoencephalitis occurred more frequently when additional water sources were supplied to the cattle during the first few weeks after arrival and tended to occur more frequently when the manger space per head was relatively restricted.

DISCUSSION

The major objective of the Bruce County Beef Project was to identify factors associated with morbidity, mortality and health-related expenses in feedlot calves. Since mortality has been the major endpoint variable much effort has been directed towards determining cause of death.

In both years of the study respiratory disease accounted for the great majority of deaths and there is very close agreement in the proportional mortality rates of specific respiratory tract diseases in the two years. The major differences in the second year of the study relate to the relative increase in ITEME and the drastic decrease — to one case — in bovine virus diarrhea (BVD). No vaccine against the latter disease was used in the second year of the project.

As in year one, mortality was the dependent variable. Most of the farmers maintained good records on morbidity and treatments but the farm to farm variation in treatment rates was extremely large. Personal observation of treatment practices also indicated that different farmers use very different criteria as a basis for initiating therapy. Since morbidity is likely to be most important because of its effects on productivity, not treatment costs *per se*, we intend to identify factors affecting

[1]Somnugen™ — Bio-ceutic Laboratories, Inc., St. Joseph, Mo. 64506. Available in Canada from M.T.C. Pharmaceuticals, 1890 Brampton Street, Hamilton, Ontario.

productivity using data collected subsequently. In the current year, the analyses stipulated that groups of cattle with greater than twice the average TREAT$PH were to be classified as "high mortality groups" irrespective of actual mortality; however, all cattle groups above this average were already classified as high mortality groups on the basis of death losses alone.

The same analytical approach was used as for year one; although the discriminant analyses were simplified to include only two groups of farms, those below the median mortality rate and those above. The utility of discriminant analysis is that it provides both unconditional — as in a simple cross tabulation — and conditional — as in stratification on potential confounding variables prior to cross tabulations and analyses with odds ratio techniques — results for both quantitative and orderable qualitative (particularly binary) variables (8). However, like most multivariate techniques, the results are not unique and are subject to variation particularly after six or more variables are included simultaneously in the discriminant function (4). For this reason, variables added after the sixth step or those variables not adding significant information to the function ($p \leqslant 0.05$) were not deemed biologically significant.

In the first year of study a number of factors were identified that were associated with mortality and the goal in the second year of the project was to ascertain the repeatability of these findings.

In summary, the results of the first years study (6) suggested that:

(a) the objectives of the farmer, including pasture utilization, growing versus fattening the cattle over winter and "finishing" their own cattle were very important over-riding factors and seemed to set the stage for the more specific factors associated with mortality;
(b) the use of cornsilage as roughage in the first month after arrival was the most important single variable associated with elevated mortality. Other ration components associated with mortality were also associated with the two major roughages hay and cornsilage;
(c) "processing" the cattle including the use of vaccines against respiratory disease appeared to increase the risk of mortality;
(d) purchasing homogeneous groups of cattle with respect to breed and not mixing groups of cattle on or after arrival were associated with low mortality and
(e) housing factors *per se* did not appear to be strongly associated with mortality.

In general, all of these results were validated by the second year's investigation.

Factors that were associated with mortality in year one but not validated in the second year of the study include; the feeding of salt in block and loose form, number of cattle per group, feeding starter rations containing antibiotics and using a manure-pack system in the lounging area. The results of the second year suggest that salt and mineral should not be fed within three weeks of arrival. After the initial three week period the feeding of salt and mineral appears to be unrelated to mortality (no differentiation was made between the two time periods in year one). Thus, the overall significance of these factors in influencing the health status of cattle is unresolved, but they probably do not exert a large effect on mortality. Some work has demonstrated decreased morbidity rates but no effect on productivity or economic return following the feeding of medicated feed or water (5).

The major factors which appear to influence feedlot calf mortality are; the use of cornsilage, mixing of cattle groups and the use of respiratory disease vaccines. Data on cornsilage usage indicate that in general it may be added to the ration a few days after the cattle arrive but it should not become the major roughage within the first month. This regime should minimize but not remove the risks associated with feeding cornsilage. In contrast, it seems that nonmixed, nonvaccinated cattle can receive large amounts of cornsilage without undue harm. Cattle groups fed cornsilage as the major roughage between two to four weeks after arrival appeared to do more poorly than expected. However, an examination of the data in the daily-logs for these cattle revealed that clinical disease and deaths were occurring concomitantly with the addition of cornsilage to the roughage or with cornsilage becoming the major component of the roughage. Thus, changes in the ration do not appear to be advisable when a significant proportion of the cattle are being treated for clinical disease.

Research on introducing calves to feedlots in the southwest USA is in agreement with our results in that high energy rations were associated with excess morbidity. However, feeding hay (long-stemmed alfalfa) was not protective against morbidity and the highest overall economic returns were realized from the use of high energy rations (5). The calves used in these studies were much younger, averaging only about 60% of the weight of calves in Bruce County. This fact together with the different environment may limit comparisons between these studies.

Other nonroughage components of the ration were investigated. In general, their use was related to the roughage being fed; with cornsilage fed cattle tending to receive nonprotein nitrogen supplementation or high energy (corn) grains; whereas the hay-fed cattle tended to be fed mixed grains (barley and/or oats). Although these items tended to be unconditionally related to mortality, most of their apparent effect disappeared after statistically controlling for the roughage being fed. Corn grain fed to hay-fed cattle appeared to exert a negative effect on mortality; however, most of this association was due to one farm in the study with many groups of cattle. Therefore the importance of this factor is equivocal.

Mixing cattle groups was associated consistently with elevated mortality. This is most likely due to

the introduction of larger numbers and/or new strains of respiratory pathogens. "Mixing" *per se* may also account for the high mortality in cattle originating from eastern Ontario or Quebec. Although the actual source of these cattle is unknown, it is likely that these groups were made up of a few cattle from many farms sorted and mixed prior to shipment to the study area.

The use of respiratory vaccines was associated with elevated mortality, particularly in silage-fed calves. Previously (6), although not statistically significant — except for BVD containing vaccines — it was suggested that vaccination was associated with high mortality, especially if performed on arrival. In the second year the data indicates that vaccinating at most times was associated with elevated subsequent mortality, and that delaying vaccination more than two days postarrival appeared to reduce the negative effects in silage-fed cattle but not in hay-fed cattle. The reasons for the negative effects are not known. Attenuated vaccines may act as "stressors" since they may elevate body temperature and produce mild upper respiratory disease (9). Vaccinated cattle, in one experiment had higher (not statistically significant) levels of morbidity and mortality than nonvaccinated cattle when introduced to a feedlot where respiratory disease was present (1). It has also been reported that the alveolar macrophages in cattle vaccinated against *Pasteurella* engulf too many *Pasteurella* organisms per cell resulting in cell damage or death, the release of intracellular enzymes and subsequent tissue damage (7). Further, some feedlot owners and veterinarians believe that "running cattle through a chute" without vaccination, etc., is sufficient to increase morbidity. Since IMWORADE was not related significantly to mortality, this seems to indicate a negative effect from vaccination above that of implanting, deworming or giving vitamin injections *per se*, all of which require some amount of handling of calves. In any event it would appear useful to re-examine the possible benefits of prevaccinating calves three to four weeks prior to shipping. Until further data are collected, it would seem advisable to delay the vaccination of feedlot calves until sometime after they are completely adjusted to their new environment; although other workers suggest vaccinating and processing should be done immediately prior to shipment or on arrival (5).

The fact that the variables MIXED and RESPVAC are important is further demonstrated by examining OFF-FARM (selected as important in series 1 to 3 analyses). Those farmers with off-farm employment tended to purchase Ontario cattle, tended not to process or vaccinate their cattle and in general, these farmers had low mortality rates in their cattle. The consistent negative effects of vaccination and mixing groups of cattle gives further credence to the harmful aspects of this practice (Table XIII and Fig. 1). In addition, Figure 1 graphically displays that excess mortality is not due to a single factor, or a single combination of factors, but that various factors and combinations thereof influence the level of mortality.

The importance of factors other than the roughage, MIXED and RESPVAC is difficult to assess because of the association among variables. Nonetheless, the negative effects of operations such as dehorning and castration have been documented (10). Injecting all calves with antimicrobials is likely a sign of imminent morbidity rather than a cause of ill-health. The authors have no explanation for the apparent importance of the variable SEGREGAT. Removing all treated cattle to a hospital pen was positively correlated with tagging and processing (IMWORADE) but not strongly correlated with ration.

In identifying factors associated with mortality in the present study we were primarily identifying those factors relating to death from the shipping-fever-complex. This year, an increase in clinical cases and deaths from ITEME and urolithiasis was noted, although few animals dying after a waterbelly episode were sent for postmortem examination. In investigating factors related to ITEME, the results indicate that ITEME shares some of the same determinants as the shipping-fever-complex particularly of cornsilage as the major roughage component. In contrast, urolithiasis does not appear to share the same risk factors as the shipping-fever-complex, but may be related to train shipment of cattle. Whether or not there is water deprivation during the period of transport that may predispose to the condition is not known. The authors could not find evidence to support the thesis that cattle from southern Alberta and Saskatchewan are at increased risk of this condition.

Based on the two years of data, we are unable to support or refute any claims relative to the overall value of using Somnugen. The vaccine as used in the field is imperfect since vaccinated cattle did develop ITEME; however, its use did appear to spare excess morbidity and mortality from ITEME. Only three farmers utilized this vaccine in year two, as in year one of the study. Data from studies of this vaccine in western Canadian feedlots have been inconclusive (3).

Finally, the authors acknowledge that the impact of disease (clinical and subclinical) on productive efficiency and economic return likely is much more important than the impact of mortality *per se*. Attempts are being made to obtain data on these latter aspects from feedlot enterprises in Bruce County. Until such data are obtained veterinarians and farmers will have to decide individually about the potential economic effects of the shipping-fever-complex and weigh any benefits from its partial control against the costs incurred in changing their management regimes.

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