Factors Associated with Mortality and Treatment Costs in Feedlot Calves: The Bruce County Beef Project, Years 1978, 1979, 1980

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ABSTRACT

Three years of data on factors associated with death losses and health costs in Ontario feedlot calves were analyzed. The results support the previously reported findings; however, significant differences in the third year (1980-81) of the study were noted.

Calf groups that were "mixed" after arrival in the feedlot or had a larger than average number of calves ($\bar{x}$ = 142) had increased death losses and health costs.

Calf groups whose ration was changed from dry hay to hay silage or corn silage as the major component of the ration during the first month after arrival had higher death losses and health costs. Feeding grain (barley/oats/corn) prior to, or concurrent with, the change to silage appeared to decrease the harmful effects.

Cattle groups vaccinated against respiratory disease within two weeks of arrival experienced increased death losses and health costs. These effects were ameliorated by delaying vaccination in groups switched to silage; however, no benefits from delaying vaccination were noted in dry hay fed groups. Prophylactic antimicrobials in the water supply during the first week after arrival appeared particularly deleterious to the health of calf groups. The effects of prophylactic antimicrobials in the starter ration were unclear.

During 1980-81, there was a marked decrease in the relative importance of fibrinous pneumonia as a cause of death and the feeding of silage was not significantly associated with mortality. Both these events may have arisen from the drastic decrease in the percentage of groups fed silage by two weeks postarrival (from 32% in previous years to 7% in 1980-81).

RÉSUMÉ

Cet article présente une analyse des observations enregistrées au cours d'une période de trois ans et relatives aux facteurs responsables des mortalités et des frais vétérinaires, chez les veaux de parcs d'engraissement de l'Ontario. Les résultats de ce project confirment ceux d'études antérieures similaires; au cours de la troisième année du projet, i.e. en 1980-1981, on enregistra toutefois des différences appréciables.

Les groupes de veaux, constitués après l'arrivée de ces derniers dans les parcs d'engraissement ou composés d'un nombre de veaux plus élevé que la moyenne ($\bar{x}$ = 142), subirent plus de mortalités et entraînèrent des frais vétérinaires plus élevés.

Les groupes de veaux dont le principal ingrédient de la ration passa du foin sec à l'ensilage de foin ou de maïs, au cours du mois qui suivit leur arrivée dans les parcs d'engraissement, affichèrent plus de mortalités et commandèrent des frais vétérinaires plus élevés. Le fait de leur donner un mélange d'orge, d'avoine et de maïs, avant ou en même temps que le passage à l'ensilage, sembla atténuer ces deux inconvénients.

Les groupes de veaux vaccinés contre les maladies respiratoires, au cours des deux semaines qui suivirent leur arrivée dans les parcs d'engraissement, connurent plus de mortalités et exigèrent des frais vétérinaires plus élevés. Le délai de cette vaccination jusqu'au temps de l'alimentation à l'ensilage, sembla amenuiser ces deux inconvénients; aucun bénéfice ne résulta toutefois d'un délai, chez les groupes qui recevaient encore encore du foin sec. L'addition prophylactique d'antibiotiques à l'eau, au cours de la semaine qui suivit l'arrivée des veaux dans les parcs d'engraissement, s'avéra particulièrement néfaste. Les effets de l'addition prophylactique d'antibiotiques à la moulée de début, demeurèrent par ailleurs indéterminés.

Au cours de l'année 1980-1981, on constata une diminution marquée de l'importance relative de la pneumonie fibrineuse, comme cause des mortalités; l'alimenta-

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tion à l'ensilage ne sembla pas par ailleurs exercer d'influence appréciable sur les mortalités. Ces deux constatations pourraient avoir résulté de la diminution drastique du pourcentage des groupes de veaux nourris à l'ensilage, aussi tôt que deux semaines après leur arrivée dans les parcs d'engraissement; cette proportion s'établissait en effet à seulement 7% en 1980, comparativement à 32% pour l'année précédente.

INTRODUCTION

During the three year period 1978-1980 a field study to identify factors influencing the health status of feeder calves was conducted in Bruce County, Ontario. The results of the first two years of study are published elsewhere (3, 4, 5).

In the third year of the project we attempted to validate previous findings and collect detailed information on rations and weight gains. This paper describes the factors associated with mortality rates or treatment costs over the three year period.

MATERIALS AND METHODS

As reported previously (3, 4) data were obtained from daily logs and expense records maintained by feedlot owners, interviews, cattle inspection and housing surveys. Calves which died were sent to the Ontario Veterinary College for necropsy.

A combined data set for the years 1978, 1979 and 1980 was formed consisting of all groups, of more than 35 calves, from farms on the study during at least two of the three years.

Each cattle group was designated as either a lot or a pen. A lot had similar characteristics with respect to source, transportation, housing, feeding and management and arrived at the feedlot within 24 hours of each other. Pens were heterogenous with respect to one or more of these factors, usually source or time of arrival.

The variables that related to all groups of cattle (Table I) were divided into management, demographic, ration and processing variables. Also, for calves that were raised in the west, it was ascertained whether they were purchased from a dealer or salesyard in the west, a dealer or salesyard in Ontario, or if the cattle came directly from the ranch of origin. For cattle coming directly to Ontario feedlots, the method of transportation; that is truck or train, the number of deaths during transit and the condition of cattle on arrival was noted. In addition to the ration variables shown, data were obtained on the feeding of salt and mineral as well as whether cattle were allowed continuous access to roughage or had to clean up what they were fed within an eight hour period. The composition of the ration for pens in 1978 on arrival and at weeks 1 and 2 was based on data collected from the

TABLE I. Selected Variables Used to Study Factors Influencing Mortality and Health-related Expenses in Feedlot Calves

Management-Objective Variables	
PASTURE:	Will you pasture these cattle next summer?
FINISH:	Will you "finish" these cattle to market weight?
FATTEN:	Will you fatten these cattle this winter?
Demographic Variables	
LOT:	Is this group a "lot"? (See Materials and Methods for definition)
MIXED:	Will this group be mixed with other cattle within three weeks?
LIVE:	No. cattle in group
WEIGHT:	Average weight of cattle in group
RAISONT:	Were these cattle raised in Ontario?
RAISWEST:	Were these cattle raised in the western provinces?
ONEBREED:	Is there one major breed or cross breed of cattle?
MALE:	Is this an all "male" group?
MIXSEX:	Is this a "mixed-sex" group?
Ration Variables	
CORNSILAGE:	The variables indicate the presence or
HAYSILAGE:	absence of each of these feedstuffs,
DRY HAY:	and whether it was the major
BARLEY/OATS:	portion of the ration at four[a]
GRAINCORN:	postarrival times.
PROTEIN:	Was a protein supplement fed within two weeks of arrival?
NONPROTEIN:	Was nonprotein nitrogen fed within two weeks of arrival?
STARTER:	Was a starter ration fed within one week of arrival?
ANTISTAR:	Did the STARTER contain antimicrobials?
Processing Variables	
SEGREGATION:	Are all treated (sick) cattle segregated?
ANTIMICROBIAL:	Were all the cattle injected with prophylactic antimicrobials within one week of arrival?
ANTIWATER:	Were preventive antimicrobials given by water within one week of arrival?
VITAMINS:	Were the cattle injected with vitamins within one week of arrival?
RESPVACC:[b]	Were IBR or IBR-PI_3 vaccines given?
$IBRPI_3$PAST:	Was this 3-way vaccine given?
$IBRPI_3$BVD:	Was this 3-way vaccine given?
HAEMOPHILUS:	Was an *H. somnus* bacterin given?
BLACKLEG:	Was a clostridial bacterin given?
IMPLANT:	Were the cattle implanted?
EXTPARASITE:	Were the cattle treated for lice or grubs?
INTPARASITE:	Were the cattle dewormed?
DEHORN:	Were the cattle dehorned?

[a] The numbers 0, 1, 2 and 4 denoted the ration content at arrival, one, two and four weeks postarrival. "M" denoted the major components of the ration

[b] For the events represented by variables, RESPVACC through INTPARASITE, the time of processing was noted

same farm the next year it was on the study. Dehorning and castration were noted only if more than 30% of the group were involved.

A number of details were recorded on the housing of the cattle groups. These included whether or not cattle had free access to outdoors, the number and type of water sources available within two weeks of arrival, the surface area of these water sources, the length of manger available for feeding, and the presence of permanent sick-pen facilities. Housing data were obtained only on groups of cattle not allowed access to pasture and not moved to another barn within three weeks of arrival.

The dependent variables; percent mortality and treatment costs per head, in the first six to eight weeks postarrival, served as general indicators of the extent of sickness. The mortality rate was transformed using $\log_{10}$ (percent mortality rate +1).

Most analyses were performed using stepwise multiple regression methods (6). The independent variables were allowed to enter the regression equation based on the magnitude of the F statistic. Variables were allowed to enter the equation until the F test of the regression equation (H_0:$b_1 = b_2 = b_j = 0$) became nonsignificant or until a maximum of six variables had been entered. Initially the variables were analyzed in specific subsets; that is, management variables were analyzed separately from demographic variables which were analyzed separately from ration and processing variables. These analyses allowed the authors to identify for example, which if any processing factors were statistically related to health status disregarding the effects of all other factors. Subsequently, two or more groups of variables were analyzed simultaneously to identify; for example , which if any processing factors were associated with health status when demographic characteristics and ration were 'held constant' statistically. In the final analyses, demographic variables were allowed to enter the equation first, followed by ration variables and finally processing variables. Discriminant analysis was used to identify differences between specific groups of cattle; for example those destined to be pastured versus those that would not be pastured in the subsequent summer (6). Additional analytic methods were used where appropriate (1).

TABLE II. A Summary of Morbidity and Mortality Rates and Health-related Expenses for Feeder Calves in the Bruce County Beef Project 1978, 79, 80

	1978	1979	1980
No. Farms in Study	66	69	54
No. Cattle Groups	104	133	110
No. Cattle	19,600	19,400	13,889
No. Deaths	230	191	137
% Mortality	1.3%	1.0%	1.0%
% Morbidity	—	28%	30%
Cost per head: prevention[a]		0.94 ± 0.71	1.17 ± 0.92
Cost per head: treatment		2.92 ± 2.61	2.81 ± 2.84

[a]Includes prophylactic antimicrobials (excluding via feed), vitamins and vaccines

RESULTS

Approximately 63 farms, 116 cattle groups and 17,600 cattle were studied in each year of the Bruce County Project (Table II). Slightly in excess of 1% of these cattle died and approximately 29% of the cattle were treated at least once. On average, feedlot owners spent approximately $1 per head on prophylaxis and $3 per head on treatment of disease, excluding handling costs.

The most frequent postmortem diagnosis (Table III) was fibrinous pneumonia which decreased in both frequency and severity in 1980-81. There was a twofold increase in the frequency of interstitial pneumonia during each of 1979-1980 and 1980-81. Bovine virus diarrhea (BVD) was not diagnosed frequently in the last two years of the study.

Of the management-objective factors examined, the variable FATTEN appeared most important, with cattle groups destined to be fattened over the first winter having a higher mortality rate than those fed for growth only (Table IV). The same tendency was found for treatment costs; although

TABLE IV. The Effect[a] of Management-Objective Factors on Mortality Rates and Treatment Costs in Feedlot Calves. Data from Bruce County Beef Project 1978, 79, 80

	Standardized Regression Coefficients	
Variables	Mortality Rate	Per Head Treatment Cost
PASTURE	-0.21%	-0.11¢
FINISH	NS	-0.07¢
FATTEN	0.56%[b]	0.11¢

[a]Implied effect based on standardized regression coefficient (beta)
[b]The effect is significant ($p<0.05$) when other variables in the equation are held constant (controlled statistically)
NS = not selected by algorithm

TABLE III. The Six Most Frequent Diagnoses at Postmortem Examination of Feedlot Calves. Data from Bruce County Beef Project 1978, 79, 80

	Number of Cases and Proportional Mortality Rate		
	Year		
Diagnoses	1978-79	1979-80	1980-81
Fibrinous Pneumonia	69(41%)	74(45%)	33(29%)
Bronchial Pneumonia	15(9%)	22(13%)	11(10%)
Interstitial Pneumonia	3(2%)	9(5%)	12(10%)
Infectious Rhinotracheitis	7(4%)	5(3%)	6(5%)
Infectious Thromboembolic Meningoencephalitis	15(9%)	22(14%)	13(11%)
Bovine Virus Diarrhea	11(7%)	1(<1%)	1(<1%)
Total Deaths	230	191	137
Total Examined	168	167	116
Percent Examined	73%	87%	85%

TABLE V. The Effect of Demographic Factors of Cattle Groups on Mortality Rates and Treatment Costs in Feedlot Calves. Data from Bruce County Beef Project 1978, 79, 80

Variables	Standardized Regression Coefficients: Mortality Rate	Per Head Treatment Costs
LOT	-0.34%[a]	NS
LIVE	0.32%	0.06¢
MALE	-0.30%	0.03¢
MIXSEX	0.22%	NS
RAIWEST	0.08%	-0.10¢
RAIONT	0.27%	0.08¢
MIXED	NS	0.12¢[a]
PURELINE	NS	-0.06¢

[a]The effect is significant ($p<0.05$) when other variables in the equation are held constant (controlled statistically)
NS = not selected by algorithm

no variables were significantly related to costs. A large number of variables differentiated groups to be fattened from those not to be fattened. Specifically, groups to be fattened contained more cattle than nonfattened groups (179 versus 121) and the ration was switched to corn silage more rapidly than in groups fed primarily for growth. The use of nonprotein nitrogen and high energy grains (corn) was also more common in the groups to be fattened.

Of the demographic factors, lots had lower mortality rates than pens of cattle and groups that were mixed with other cattle had higher treatment costs than nonmixed cattle groups (Table V). Most nonmixed groups were lots, and when the variable MIXED was deleted, the type of group (lot versus pen) had a significant effect on treament costs and on mortality rate. The major differences between lots and pens appeared to be that lots contained fewer cattle (99 versus 172), a higher percentage of lots were fed low energy grains and a significantly lower percentage of lots were fed corn silage than pens of cattle. Significantly more lots than pens were given injectable vitamins and *Haemophilus somnus* bacterin.

When the effect of ration during the first month postarrival was investigated, corn silage as the major component of the ration, and hay silage were associated with increases in mortality (Table VI). The same trend was present for treatment costs but no factor was significantly associated with treatment costs (Table VI).

The highest mortality rates and treatment costs occurred in cattle groups being fed corn silage as the major component of the ration by one week postarrival (Tables VIIa and VIIb). The groups fed corn silage as the major component by two weeks postarrival appeared to have lower mortality rates and treatment costs than those fed corn silage as the major component by week 4. Those fed corn silage in any amount during the first week,

TABLE VI. The Effect of Ration Variables on Mortality Rates and Treatment Costs in Feedlot Calves. Data from Bruce County Beef Project 1978, 79, 80

Variables	Standardized Regression Coefficients: Mortality Rate	Per Head Treatment Costs
PASTFED	0.03%	-0.51¢
CORN-SILAGE	-0.34%	NS
HAY-SILAGE	0.35%[a]	0.46¢
CORN-SILAGE(M)	0.97%[a]	0.52¢
GRAIN-CORN	-0.05%	NS
BARLEY/OATS	NS	-0.42¢
PROTEIN	0.09%	0.34¢
NON-PROTEIN	NS	-0.73¢

[a]The effect is significant ($p<0.05$) when other variables in the equation are held constant (controlled statistically)
NS = not selected by algorithm

TABLE VIIa. Mortality Rates in Feedlot Calves According to Ration Composition[a] at Selected Times Postarrival. Data from Bruce County Beef Project 1978, 79, 80

CORNSILAGE Initially fed by week	Cornsilage became major component by week: 1	2	4	>4	Average(s)	
1	1.12% (15)	0.76% (9)	1.67% (5)	0.23% (7)	0.93 (36)	
2	—	0.58% (17)	0.83% (15)	0.38% (8)	0.63 (40)	0.72 (120)
4	—	—	0.75% (28)	0.48% (16)	0.65 (44)	
Average(s)	1.12% (15)	0.64% (26)	0.85% (48)	0.39% (31)		
		0.83 (89)				

[a]Mortality Rates in noncornsilage-fed calves was 0.50% and 0.42% in dry hay-fed calves
( ) No. of groups

TABLE VIIb. Treatment Costs (Per Head) in Feedlot Calves According to Ration Composition[a] at Selected Times Postarrival. Data from Bruce County Beef Project 1978, 79, 80

CORNSILAGE Initially fed by week	Cornsilage became major component by week: 1	2	4	>4	Average(s)	
1	$4.13 (9)	$2.63 (7)	$5.20 (3)	$1.93 (5)	$3.37 (24)	
2		$3.95 (15)	$3.61 (12)	$2.24 (7)	$3.47 (34)	$3.15 (92)
4			$2.47 (22)	$3.07 (12)	$2.68 (34)	
Average(s)	$4.13 (9)	$3.53 (22)	$3.06 (37)	$2.59 (24)		
		$3.35 (68)				

[a]Treatment costs for noncornsilage-fed calves $2.73
( ) No. of groups

on average, had higher mortality rates than those introduced to corn silage later. The 31 groups fed corn silage during the first month, but never as the major component of their ration during that period had fewer health problems than the remaining groups fed corn silage and slightly better than those fed dry hay.

The relationship between grain feeding (corn or barley/oats) to silage-fed calves and mortality rates and treatment costs are shown in Tables VIIc and VIId, respectively. Grain feeding appeared to improve the health status of calves whether it was concommitant with or preceded silage feeding. The suggestion that grain feeding might be sparing was derived from the consistent sparing effect — usually nonsignificant — observed in Tables VI and IX, and the significant sparing effect of feeding corn grain in groups not receiving starter rations, antimicrobials in the water or BVD vaccines (Table IX).

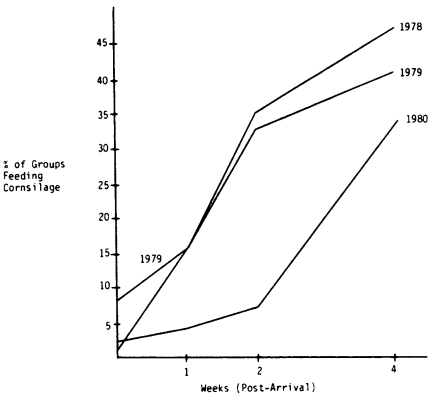


Fig. 1. The percent of cattle groups being fed corn silage according to time postarrival and year. Data from Bruce County Beef Cattle Project 1978, 79, 80.

The delay in the introduction of corn silage during the third year (1980) of the project is shown in Fig. 1. By two weeks postarrival, only 7% of cattle groups in 1980 had corn silage included in their ration; whereas 32-35% had corn silage in their ration in 1978 and 1979. Furthermore, there appeared to be a gradual decline in the percentage of cattle groups receiving corn silage during the first month after arrival in the years 1978 through 1980 inclusive.

The use of respiratory vaccines, antimicrobials in the water, and dehorning within two weeks of arrival were associated with increased mortality rates (Table VIII). Anthelmintics and prophylactic antimicrobials in the water supply both were associated with increased treatment costs (Table VIII). The IBRPI$_3$PAST vaccines were used primarily only in 1978 and the IBRPI$_3$BVD vaccines were only used in 1978.

In corn silage fed groups, vaccines intended to prevent respiratory disease were associated with increased mortality rates (Table IX). The use of starter rations within one week postarrival or the feeding of barley/oats was associated with decreased treatment costs. Prophylactic antimicrobials in the water supply were associated with increased treatment costs (Table IX).

In hay fed groups of calves, only RESPVACC was significantly

TABLE VIII. The Effect of Processing Variables on Mortality Rates and Treatment Costs in Feedlot Calves. Data from Bruce County Beef Project 1978, 79, 80

	Standardized Regression Coefficients	
Variables	Mortality Rate	Per Head Treatment Cost
ANTI-WATER	0.32%[a]	0.16¢[a]
ANTI-MICROBIAL	NS	0.04¢
VITAMINS	-0.36%	-0.11¢
IBRPI$_3$BVD	0.20%	NS
RESPVACC	0.62%[a]	0.07¢
EXTPARA-SITE	NS	0.04¢
INTPARA-SITE	NS	0.17¢[a]
DEHORN	0.39%[a]	NS
HAEMO-PHILUS	-0.24%	NS

[a]The effect is significant ($p < 0.05$) when other variables in the equation are held constant (controlled statistically)
NS = not selected by algorithm

TABLE VIIc. Mortality Rates in Feedlot Calves According to Ration Composition at Selected Times Postarrival. Data from Bruce County Beef Project 1978, 79, 80

CORNSILAGE initially fed by week	GRAIN initially fed by week			
	1	2	4	Not fed
1	0.48% (15)	0.66% (13)	1.66% (5)	1.24% (3)
2	0.49% (7)	0.67% (12)	0.59% (18)	0.78% (3)
4	0.50% (10)	0.86% (12)	0.70% (5)	0.73% (16)
Average(s)	0.49% (32)	0.73% (37)	0.80% (28)	0.81% (22)

( ) No. of groups

TABLE VIId. Treatment Costs (Per Head) in Feedlot Calves According to Ration Composition at Selected Times Postarrival. Data from Bruce County Beef Project 1978, 79, 80

CORNSILAGE initially fed by week	GRAIN initially fed by week			
	1	2	4	Not fed
1	$3.51 (7)	$2.19 (5)	$3.82 (3)	$3.76 (9)
2	$3.85 (9)	$2.70 (16)	$3.93 (2)	$4.65 (7)
4	$2.26 (11)	$4.00 (5)	$2.50 (12)	$1.20 (5)
Average(s)	$3.11 (27)	$2.85 (26)	$2.90 (17)	$3.45 (21)

( ) No. of groups

TABLE IX. The Effect of Ration and Processing Factors on Mortality Rates and Treatment Costs in Cornsilage-fed Feedlot Calves. Data from Bruce County Beef Project 1978, 79, 80

Variables	Standardized Regression Coefficients	
	Mortality Rate	Per Head Treatment Cost
GRAIN-CORN	-0.16%	NS
BARLEY/OATS	NS	-0.19¢[a]
SEGREGATION	0.12%	0.13¢
ANTI-WATER	0.25%	0.26¢[a]
IBRPI$_3$BVD	0.78%[a]	NS
RESPVACC	0.29%[a]	0.15¢
VITAMINS	-0.16%	NS
STARTER1	NS	-0.21¢[a]
INTPARA-SITE	NS	-0.14¢

[a]The effect is significant ($p < 0.05$) when other variables in the equation are held constant (controlled statistically)
NS = not selected by algorithm
CORNSILM was entered first in initial analysis, and no other factors contributed significantly to the regression. CORNSILM was deleted from the present analysis. When groups of cattle fed STARTER, ANTIWATER or given IBRPI$_3$BVD were deleted, GRAINCORN had a significant sparing effect on mortality rates; whereas RESPVACC significantly increased treatment costs

TABLE X. The Effect of Ration and Processing Factors on Mortality Rates and Treatment Costs in Hay-fed Feedlot Calves. Data from Bruce County Beef Project 1978, 79, 80

Variables	Standardized Regression Coefficients	
	Mortality Rate	Per Head Treatment Cost
STARTER0	-0.37%	NS
STARTER1	NS	+0.16[a]
ANTI-MICROBIAL	NS	0.08
ANTI-WATER	0.30%[a]	0.15[a]
IBRPI$_3$BVD	NS	-0.15
RESPVACC	0.64%[a]	NS
HAEMO-PHILUS	-0.29%	0.13
INTPARA-SITE	0.24%	NS
VITAMINS	-0.35%	-0.10

[a]The effect is significant ($p < 0.05$) when other variables in the equation are held constant (controlled statistically)
NS = not selected by algorithm
When cattle groups given STARTER, ANTIWATER, IBRPI$_3$BVD or HAEMOPHILUS were deleted, no ration or processing variables were related significantly to treatment costs; RESPVACC significantly increased mortality rates

associated with increased mortality rates. Antimicrobials in the water supply or feeding commercial starter rations during the second week postarrival were associated with increased treatment costs. Using vaccines against respiratory disease was associated with increased health problems in groups of calves that did not receive starter rations, antimicrobials in the water supply, bovine virus diarrhea or haemophilus vaccines (Table IX and X), irrespective of ration. Delaying vaccination in corn silage fed cattle appeared to reduce the negative effect of vaccination (Table XI); but no such reduction was seen in hay fed cattle.

When the effects of demographic, ration and processing factors were examined simultaneously, type of group (lot versus pen), feeding corn silage as the major component of the roughage, using vaccines against respiratory disease and feeding hay silage were the only variables with a significant effect on mortality rate. Using antimicrobials in the water supply was harmful at $p < 0.10$ but not at $p < 0.05$.

In hay fed groups, larger groups had a significantly increased mortality rate; whereas, using starter rations (most containing antibiotics) during the second week postarrival significantly increased treatment costs. In hay fed groups not receiving starter rations or antimicrobials in the water supply, the larger groups experienced increased mortality rates and groups vaccinated with *H. somnus* bacterins experienced increased treatment costs.

In corn silage fed groups, using IBRPI$_3$BVD and/or mixing cattle groups were associated with significantly increased mortality rates; while, using antimicrobials in the water supply during the first week, significantly increased treatment costs and feeding starter rations during the second week postarrival significantly reduced treatment costs. In groups not receiving starter ration or antimicrobials in the water supply, IBRPI$_3$BVD was associated significantly with increased mortality rates; whereas, feeding corn grain was associated significantly with decreased mortality rates and using vaccines against respiratory disease was associated with significantly increased treatment costs.

The effects of ration, respiratory vaccines and group type (lots versus pens) are summarized in Table XII and Fig. 2. In general, the mortality rate increased directly with the imposition of these three negative factors. Vaccination of lots of hay fed cattle appeared to exert a much greater effect than in similar groups of corn silage fed cattle. If feeding corn silage, having pens of cattle and using respiratory vaccines are assumed to be causes of the increased mortality, then approximately 58% of all deaths in the cattle under study can be attributed to these factors.

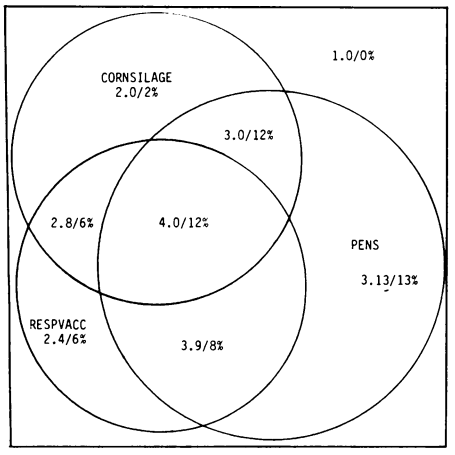
DISCUSSION

In drawing inferences from the Bruce County Beef Project data the authors have attempted to use accepted epidemiological criteria to infer causation from observed statistical associatons (8, 9). These

TABLE XI. The Relationship Between Time of Vaccination, Ration and Mortality Rate in Feedlot Calves. Data from Bruce County Beef Project 1978, 79, 80

Time of Vaccination[a] (postarrival)	Corn Silage fed groups	Dry Hay fed groups
< 48 hrs	0.86% (31)	0.54% (37)
> 48 hrs 2 weeks	1.16% (6)	0.82% (8)
> 2 weeks 4 weeks	0.60% (21)	0.71% (20)
Not vaccinated	0.63% (62)	0.34% (101)

[a]Includes IBR, IBRPI$_3$ (intranasal and intramuscular) and IBRPI$_3$PAST. IBRPI$_3$BVD excluded
( ) No. of groups



Relative Risk/Population Attributable Risk %
- See Table XII for definitions

Fig. 2. A pictorial representation of the effects and importance of CORNSILAGE, "PENS" and RESPVACC on mortality rates in feedlot calves. Data from Bruce County Beef Cattle Project 1978, 79, 80.

criteria include time sequence, strength of association, consonance and particularly consistency of results on replication. Thus, although directed by the results of formal analyses, most inferences, to some extent, go beyond the available data.

Stepwise multiple regression was used to identify factors that might have influenced mortality or treatment costs to a statistically significant degree. This method is similar to discriminant analysis used previously (5) and the results are easier to interpret (6). Mortality rate and/or treatment costs were indicators of the extent of disease in a group of cattle and the absolute change in these was not of primary importance except as a means of ranking selected factors according to their relative impact on the health status of groups of calves. Treatment cost was used as a balanced indicator of both incidence rate and duration of disease.

The information derived from necropsies was appreciated by the feedlot owners and collaborating practitioners and together with field observations, provided an ongoing picture of the syndromes responsible for clinical disease and death in feedlot calves. Fibrinous pneumonia was the most important cause of death being responsible for 40-45% of all deaths, in agreement with results of other studies (2, 7). However, the drastic decrease in fibrinous pneumonia, both in frequency and severity, during 1980 and the gradual increase in frequency of interstitial pneumonia were not anticipated and are not readily explained. The overall death loss was approximately 1%, in all years, and the unexamined dead calves — 15% to 27% of dead calves — were unlikely to have been an explanation for the changes in proportional mortality rates (8). The decrease in clinical bovine virus diarrhea subsequent to ceasing vaccination against this disease may be noteworthy.

Based on the first two years of this project, it was concluded that feeding corn silage, mixing cattle groups and using respiratory disease vaccines were major factors influencing the health status of groups of feedlot calves (5). The results of the third year tend to validate this conclusion and will now be discussed further.

The finding that groups of cattle destined to be 'fattened' during the first winter had significantly elevated mortality did not provide direct information of a cause and effect nature. However, the larger group sizes and feeding of corn silage to groups destined to be fattened were suggestive of factors more directly related to health status. Because the variable FATTEN did not appear to represent a direct risk factor, it was not included in further analyses.

Three demographic factors; namely, the group type (i.e. lot versus pen), the number of cattle per group and "mixing" of cattle groups were associated significantly with mortality. The group type appeared to be more important than the number of cattle per group; since the latter had no significant effect when group type was controlled statistically. MIXED was strongly correlated

TABLE XII. A Summary of the Effects and Importance of CORNSILAGE, LOT and RESPVACC[a] on Mortality Rates in Feedlot Calves. Data from Bruce County Beef Project 1978, 79, 80

CORNSILAGE	Variable(s) PEN	RESPVACC	Prevalence of Groups[b]	Mortality Rate (%)	Relative Risk (RR)[c]	Population Attributable Risk % (PAR%)[d]
Y	Y	Y	0.10	0.93%	4.04	11.6%
Y	Y	N	0.15	0.70%	3.04	11.8%
Y	N	Y	0.09	0.64%	2.78	6.1%
Y	N	N	0.06	0.46%	2.00	2.3%
N	Y	Y	0.07	0.90%	3.91	7.8%
N	Y	N	0.16	0.72%	3.13	13.1%
N	N	Y	0.15	0.56%	2.43	5.5%
N	N	N	0.22	0.23%	1.00	0.0%
Average, or Total				0.60%		58.2%

A "PEN" is the converse of "LOT"
[a] Includes IBRPI$_3$PAST but not IBRPI$_3$BVD
[b] The proportion of groups treated in this manner
[c] Average rate of mortality in each CORNSILAGE — PEN — RESPVACC group divided by the rate of mortality in "lots" of dry hay-fed, nonvaccinated cattle groups.The latter is arbitrarily set to "1" so that the RR are "indexed" to this base. (See Ref. No. 8)
[d] This describes the percentage of all deaths that is attributable to each of the CORNSILAGE — PEN — RESPVACC groups. In all, these three risk factors account (directly or indirectly) for 58.2% of all deaths. (See Ref. No. 8)

with group type; since by definition all pens of cattle were mixed. In almost all instances, mixing was by the purchase of cattle from different sources or the addition of cattle during the first week. Mixing western and eastern calves in the same group appeared to be particularly harmful. Some lots were mixed also; but retained their identity because of ear tagging or being a distinct breed. On average the mixed lots remained as healthy as the unmixed lots; however, the majority of mixed lots were located on one farm and this may represent a farm effect.

Changing the ration by the addition of large amounts of corn silage or, less frequently, hay silage was strongly associated with an increased risk of death or increased health costs. From the results in Tables VIIa and VIIb it is inferred that the negative effects of corn silage arise when it becomes the major component of the roughage portion of the ration, within four weeks of arrival. Although some cattle groups can be fed corn silage within one week of arrival the authors recommend that calves should be fed dry hay only for two to three weeks before silage is added. In addition, silage should not be added to the ration while the group of cattle are still experiencing an elevated rate of disease(s).

The 31 groups of corn silage fed cattle that did not receive corn silage as the major component of the roughage within one month of arrival contained fewer cattle (144 versus 172) than those groups switching to corn silage as the major roughage and experienced considerably less health problems than the latter groups. When the effects of ration and processing were examined in silage fed groups (Table IX) the feeding of barley/oats or grain corn appeared to reduce health problems and grain-corn feeding was associated with lower mortality in calf groups not receiving starter rations, antimicrobials in the water or $IBRPI_3BVD$ vaccine. Thus, if one is going to feed silage, the addition of concentrate may reduce the harmful effects of silage (Tables VIId and VIIe). In separate analyses, our data indicate that regardless of the roughage being fed, cattle should not be allowed free access to roughage but rather be forced to "clean-up" the mangers before the next days feeding commences. Most likely, this practice enables the feeder to spot diseased calves more easily than in the continuous feed supply situation.

With regard to processing factors, giving proplylactic levels of antimicrobials in the water supply, using vaccines against respiratory disease, dehorning greater than 30% of the group and deworming cattle within two weeks of arrival all had a negative impact on the health of groups of calves. Giving antimicrobials in the water supply (prophylactically) and using vaccines against respiratory disease, including attenuated bovine virus diarrhea vaccines, remained as harmful factors when corn silage fed cattle and hay fed cattle groups were analyzed separately. Thus, the data indicate that prophylactic antimicrobials in the water and vaccination against respiratory disease within two weeks of arrival is contraindicated for most groups of cattle. Further, whereas delaying vaccination until two or four weeks postarrival reduced the negative effects in silage fed cattle, no such amelioration was seen in hay fed cattle (Table XI). Although the authors do not have data on which to base our decision, our general recommendation is to delay vaccination at least three weeks until the cattle are fully settled and environmental conditions are appropriate. The negative effects attributed to vaccination may be a reflection of a "handling stress" and not vaccination *per se*. However, although never significant, use of vitamin injections, also requiring handling, appeared to improve the health status of animals and thus, it appears that vaccination itself is the harmful factor.

Starter rations fed within the first week after arrival were associated with reduced mortality in hay fed cattle. Starter rations fed during the second week after arrival had a significant negative association with treatment costs in corn silage fed cattle but a significant positive association in hay fed cattle. Because of these differences and the small number of groups, only 12 contained antimicrobials, the authors are hesitant to make a recommendation on this matter.

No housing factors were significantly related to mortality rates or treatment costs. This has been a consistent finding throughout the study but may relate to the authors inability to select and appropriately quantify the correct housing factors. Restricted surface area of water has been associated with increased occurrence of urolithiasis (4).

Transportation method (truck versus train) did not play an important role in influencing the health status of groups of calves. This may represent the state of nature within Bruce County; however, in other areas of Ontario with different requirements and conditions for truck and/or train shipment differences may exist. Not surprisingly, the condition of calves on arrival was strongly correlated with subsequent health status (i.e. poor groups perform poorly).

In the authors opinion, a multitude of factors influence the health status of cattle. Because of the relatively crude endpoints — undifferentiated mortality and morbidity — the inability to quantify factors such as amount of corn silage fed per head per day, and to obtain weight gain information the authors are prepared to make general recommendations only. In Table XII and Fig. 2 we attempt to portray how three risk factors; namely, feeding corn silage, type of cattle group (mixing?) and the use of respiratory vaccines combine to increase the risk of disease or death. While other factors, identified in this study, modify the health status of calves, these latter factors appear to be the more important risk factors.

The authors are also mindfull that in multiyear observational

studies, the findings of one year may influence the management strategies in the next year. Probably, our initial findings altered the use of corn silage as a roughage. The use of vaccines increased slightly over the duration of the project (46% of groups in 1978-79 were given respiratory vaccines versus 53% in 1980-81). However in 1978-79, 86% of the vaccinated groups were vaccinated by two weeks postarrival; whereas, only 56% of vaccinated groups were vaccinated by two weeks postarrival in 1980-81. Many other changes probably occurred over the three years and the effect these had on the health status of feeder calvers remain unknown. Despite this, the authors see a need to study health and disease under on-farm conditions. It is hoped that this project will stimulate further studies of this nature.

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GRAND OPENING!

The Canadian Veterinary Medical Association's new headquarters in Ottawa (339 Booth Street) will be officially inaugurated between 4 and 7 pm on Sunday, October 31, 1982. Refreshments will be served.

We hope the Minister of Agriculture for Canada, the Honourable Eugene Whelan, will accept our invitation to cut the official ribbon at approximately 5 pm.

All CVMA members are invited to attend; we would appreciate hearing from you before October 26 (613-236-1162).

GRANDE INAUGURATION!

Le nouveau siège social de l'Association canadienne des vétérinaires, à Ottawa (339, rue Booth) sera officiellement inauguré le dimanche 31 octobre prochain, entre 16 et 19 heures. Des rafraîchissements seront servis.

Nous espérons que le ministre canadien de l'Agriculture, l'honorable Eugene Whelan, acceptera notre invitation de couper le ruban traditionnel vers les 17 heures.

Tous les membres de l'ACV sont invités à venir faire un tour; veuillez nous aviser avant le 26 octobre (613-236-1162).