

## FACTORS ASSOCIATED WITH HIGH SCOURS MORTALITY AMONG PREWEANED DAIRY HEIFERS

### FACTORES ASOCIADOS CON ALTA MORTALIDAD POR DIARREA EN TERNERAS ANTES DEL DESTETE

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#### ADDITIONAL KEYWORDS

National survey, Risk factor analysis.

#### PALABRAS CLAVE ADICIONALES

Encuesta nacional, Análisis de factores de riesgo.

#### SUMMARY

In a national survey of United States dairy operations, 1,857 (3.9 percent) of 47,057 preweaned dairy heifer calves that had been born alive or had moved onto 1,685 dairy operations over a three month period died of scours.

Stepwise logistic regression was used twice to identify management practices associated with high mortality due to scours among preweaned heifers in dairy operations where at least three dairy heifer calves were born alive or moved onto the operation: once by separating operations by size into high or low scour death categories; again using only operations with <2 percent and >10 percent mortality due to scours.

The following dairy operation characteristics were associated with high death levels due to scours in both models: rolling herd average milk production < 9,072 kg; placing preweaned calves in groups of 7 or more; housing preweaned calves in individual hutches; a male had primary responsibility for the care and feeding of preweaned heifers.

#### RESUMEN

En una encuesta nacional de los productores lecheros en los Estados Unidos de Norteamérica, 1,857 (3,9 p.100) de 47.057 terneras que nacieron vivas o que fueron introducidas a explotaciones lecheras durante un período de tres meses se murieron de diarrea antes del destete. La regresión logística fue repetida dos veces para identificar prácticas zootécnicas asociadas con mortalidad alta causada por diarrea antes del destete en explotaciones donde por lo menos tres terneras nacieron vivas o fueron introducidas a la explotación: una vez separando las explotaciones por magnitud en categorías de alta o baja mortalidad de diarrea; otra vez usando solamente explotaciones de <2 p.100 y >10 p.100 de mortalidad causada por diarrea. Las características siguientes fueron asociadas con alta mortalidad causada por diarrea en los dos modelos: el promedio móvil de producción de leche < 9,072 kg; grupos de terneras  $\geq 7$ ; alojamiento de terneras en chozas individuales; un hombre tenía responsabilidad para cuidar y alimentar las novillas.

## INTRODUCTION

Calf mortality is a major cause of economic loss to the dairy industry (Martin and Wiggins, 1973; Oxender *et al.* 1973). The United States National Animal Health Monitoring System (NAHMS) 1991 to 1992 National Dairy Heifer Evaluation Project (NDHEP) reported a mean death loss of  $8.4 \pm 0.4$  percent of preweaned heifers in dairy farms (USDA, 1993). Scours accounted for the majority of deaths among preweaned heifers:  $52.2 \pm 2.6$  percent of total mortality. In addition, scours was the most common illness among preweaned dairy heifers on  $53.8 \pm 1.8$  percent of operations (USDA, 1993).

Previous reports used NDHEP data to examine relationships between management practices and deaths attributable to respiratory problems (Losinger and Heinrichs, 1996b) and overall mortality (Losinger and Heinrichs, 1997) among preweaned dairy heifers. The dairy industry needs more knowledge on the relationship between management practices and scours mortality among preweaned dairy heifers. The objective of this technical note was to report information from the NDHEP on relationships between dairy operation management practices and deaths due to scours among preweaned dairy heifer calves.

## MATERIALS AND METHODS

The NDHEP was a year-long study designed to furnish national-level information on the management and health of dairy cattle on dairy operations in the United States (Heinrichs *et al.* 1994).

On a questionnaire administered by USDA:National Agricultural Statistics Service (NASS) enumerators, dairy producers reported the number of dairy heifer calves that had been born alive or had moved onto the operation during the three months prior to the interview, the two leading causes of death among preweaned dairy heifers, and the number of preweaned dairy heifer calves that had died from each cause on the operation during the three months prior to the interview. The producers also furnished herd-level data on management practices.

Procedures similar to those previously described were followed to identify management practices associated with high mortality due to scours among preweaned dairy heifer calves (Losinger and Heinrichs, 1996b; Losinger and Heinrichs, 1997). Analyses were limited to dairy operations where the producer reported that  $\geq 3$  dairy heifer calves were born alive or moved onto the operation during the 3 months prior to the interview. To compare solutions, stepwise logistic regression was used to build models twice: once using all dairy operations with  $\geq 3$  new dairy heifer calves, and again using only operations with  $\geq 3$  new dairy heifer calves and  $< 2$  percent or  $> 10$  percent mortality due to scours.

For the first model, dairy operations were assigned to either a low scour death level category or a high scour death level category based on the number of dairy heifer calves that had been born alive or that had been introduced to the dairy in the three months prior to the interview, and the number of deaths attributed to scours among preweaned dairy heifer calves over the same time period (**table 1**). The number of deaths due to scours was only reported if the producer reported

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that scours was either the leading or second leading cause of death among preweaned heifers. Operations that did not report scours as the leading or second leading cause of death were assigned to the low scour death rate category.

Thirty herd-level management variables previously listed (Losinger and Heinrichs, 1997) were initially examined for differences in scour death level category using the chi-square test (Hogg and Craig, 1978), available in the FREQ procedure of SAS (SAS, 1990). A herd-level management practice was defined as a practice which the producer generally applied on his operation, and did not necessarily apply to all preweaned dairy heifers on the operation. The chi-square test served as a primary screening to decide whether individual herd-level management practices should be offered for multivariable logistic regression modelling. Management variables with  $p < 0.10$  were considered to have passed the initial screening. To identify potential collinearities among the explanatory variables, Spearman correlation coefficients (Hogg and Craig, 1978) were examined using the CORR procedure of SAS (SAS, 1990).

The logistic regression of the SAS PROBIT procedure (SAS, 1989) was used to build a multivariable logistic regression model (Hosmer and Lemeshow, 1989) using only dairy operations that had provided data for all of the screened variables. The logarithm of the odds of a dairy operation falling in the high death level category was the dependent variable. To prevent variables from entering the model merely because of regional or herd size differences, region and the number of dairy heifer calves

born alive or moved onto the operation in the three months prior to the interview were forced into the model. The latter variable was reflective of both herd size and the manner in which dairy operations were assigned to death level categories. Region and herd size were both reflective of the study design (Heinrichs, 1994). Stepwise variable selection method was employed to develop the final logistic regression model (Hosmer and Lemeshow, 1989).

The above methodology was followed again using only dairy operations with  $< 2$  percent or  $> 10$  percent mortality due to scours.

## RESULTS

For 1,685 producers who reported that at least one dairy heifer calf had been born alive or had moved onto his or her dairy operation in the 3 months prior to the interview, the number of dairy heifer calves ranged from one to 1,370, and totaled 47,057 calves. Producers that had listed scours as the leading or second leading cause of death reported that 1,857 preweaned heifers (about 3.9 percent) had died of scours over the same time period. These are unweighted totals only, and therefore differ from previously reported weighted national estimates (Heinrichs *et al.*, 1994; USDA, 1993). Sixty-one operations where the producer had indicated that only one or two dairy heifer calves had been born alive or had entered the operation in the 3 months prior to the interview were not assigned to a death level category. No deaths of preweaned heifers were reported among these 61 operations.

**Table I.** Number of dairy operations with high or low mortality levels due to scours among preweaned dairy heifers by number of calves born alive or introduced per operation during the 3-month period prior to interview. (Número de explotaciones lecheras con niveles altos o bajos de mortalidad de terneras por diarrea antes del destete, en función del número de animales nacidos vivos o introducidos en la explotación durante un periodo de tres meses antes de la encuesta).

Number of dairy heifer calves	Scours mortality rate*				total
	Low		High		
	number	percent	number	percent	
3 to 16	721	80.0	180	20.0	901
17 or more	532	73.6	191	26.4	723
3 or more	1253	77.2	371	22.8	1624

\*Operations were categorized with respect to scours mortality as follows: operations with 3 to 16 new dairy heifer calves: no reported deaths due to scours=low;  $\geq 1$  reported death due to scours=high. For operations with  $\geq 17$  new dairy heifer calves:  $<6$  percent reported deaths due to scours=low;  $\geq 6$  percent reported deaths due to scours=high. Sixtyone operations with  $<3$  new dairy heifer calves were not assigned to a scours mortality category.

**Table I** reveals the result of the scheme for assigning dairy operations to categories based on deaths due to scours. **Table II** shows observed regional differences.

The construction of the logistic regression model was based on 1,546 dairy operations that had provided responses to each of the screened variables (**table III**). Among the model variables, placing preweaned calves in groups of  $\geq 7$  was obviously correlated with placing preweaned heifers in individual hutches ( $\rho = -0.276$ ). However, because some operations used both systems, the two variables were not mutually exclusive. Of 687 operations that reported placing preweaned dairy heifers in individual hutches, 47 (6.8 percent) also reported placing preweaned dairy heifers in groups of 2 to 6, and 61 (8.9 percent) also reported placing preweaned dairy

heifers in groups of 7 or more. The correlations between these two model variables did not appear to affect the significance of other explanatory variables in the model.

Removing dairy operations that did not have very low ( $<2$  percent) or high ( $>10$  percent) mortality due to scours left 1,329 dairy operations (**table IV**). The construction of the logistic regression model for these dairies was based on 1,268 dairy operations that provided responses to all of the screened variables (**table V**). The results were similar to the analysis using the larger data set, except that two additional variables entered the model.

## DISCUSSION

Because dairy operations with  $<30$

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dairy cows were not included in the NDHEP (Heinrichs *et al.*, 1994), the results of the present study do not necessarily apply to dairy operations with <30 dairy cows, nor to operations that had <3 new dairy heifer calves during the 3 month time period. In addition, the results of the study were limited to states included in the NDHEP.

NDHEP respondents only provided the leading and second leading causes of death over the 3 months prior to interview, and the number of deaths caused by each. If two illnesses other than scours were the leading causes of death on an operation, then the number of deaths due to scours was not reported. Thus, missclassification would have occurred if a dairy operator had enough deaths due to scours to fall in the high scour death category, but the number of deaths due to two other causes exceeded the number of deaths due to scours. Moreover, if a

preweaned heifer died of more than one illness (for example, pneumonia and scours combined), the operator was required to choose the perceived major cause. Nationally, scours accounted for  $52.2 \pm 2.6$  percent of deaths among preweaned heifers, and respiratory problems accounted for  $21.3 \pm 1.6$  percent of deaths (USDA, 1993). Waltner-Toews *et al.* (1986) reported an association between scours and pneumonia in Holstein heifer calves. The leading and second leading causes of death did account for the large majority (92.5 percent) of preweaned dairy heifer deaths. Thus, the NDHEP did afford a comparison between dairy operations where high heath levels due to scours were detected and operations where high death levels due to scours were not detected, based on the operators responses.

Arbitrariness in the assignment of

**Table II.** Distribution of operation size by region. (Distribución del tamaño de las explotaciones por regiones).

region	Number of dairy heifer calves born alive or moved onto operation:				
	3 to 16		17 or more		3 or more number
	number	percent	number	percent	
West	78	24.2	245	75.9	323
Midwest	449	71.4	180	28.6	629
Northeast	246	66.3	125	33.7	371
Southeast	128	42.5	173	57.5	301
Total	901	55.5	723	44.5	1624

The participating states included in each region were as follows:

West: California, Colorado, Idaho, Oregon and Washington;

Midwest: Illinois, Indiana, Iowa, Michigan, Minnesota, Nebraska, Ohio and Wisconsin;

Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New York, Pennsylvania, Rhode Island and Vermont;

Southeast: Alabama, Florida, Georgia, Maryland, North Carolina, Tennessee and Virginia.

**Table III.** Results of stepwise logistic regression for risk factors of an operation being in the high scour death level category for preweaned dairy heifer calves during the 3-month period prior to interview. (Resultados de la regresión logística por etapas para los factores de riesgo de una explotación en la categoría de alto riesgo de muerte por diarrea para las terneras no destetadas durante los tres meses anteriores a la encuesta).

Variable/ Response	Odds ratio	95 percent CI	p
Number of dairy heifer calves born alive or moved onto operation			
3 to 16	0.793	0.607 to 1.036	0.089
17 or more	1		
Region			
Midwest	0.664	0.471 to 0.935	0.019
Northeast	0.595	0.403 to 0.880	0.009
Southeast	0.690	0.468 to 1.017	0.061
West	1		
Rolling herd average milk production			
<7,258 kg	2.009	1.329 to 3.038	0.001
7,258 to 9,072 kg	1.574	1.071 to 2.313	0.021
>9,072 kg	1		
Grouping of preweaned heifers			
Not grouped	0.673	0.480 to 0.942	0.021
2-6 in group	0.572	0.368 to 0.889	0.013
>6 in group	1		
Sex of person primarily responsible for care of preweaned dairy heifers			
Male	1.566	1.183 to 2.073	0.002
Female	1		
Calves are housed in individual hutches			
Yes	1.398	1.074 to 1.821	0.013
No	1		

dairy operations into high and low scours death level categories was inevitable. In the first method, one death due to scours represented from 6.25 percent (for operations with 16 new calves) to 33.3 percent (for operations with 3 new calves) in the lowest operation size category. In the second method, which eliminated operations with between 2 percent and 10 percent mortality due to scours, no

operations with  $\geq 9$  new dairy heifers could have been eliminated, since one death due to scours was already  $\geq 10$  percent of the dairy heifers. Thus, only dairy operations with  $\geq 10$  new dairy heifer calves could have been eliminated from the analysis. An analysis using a continuous dependent variables (e.g., percent of deaths attributable to scours) would have been invalid because of

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**Table IV.** Number of dairy operations with <2 percent and >10 percent mortality due to scours among preweaned dairy heifers by number of dairy heifer calves born alive or introduced to the operation during the 3-month period prior to interview. (Número de explotaciones lecheras con menos del 2 p. 100 y más del 10 p. 100 de mortalidad por diarrea en terneras antes del destete según el número de terneras nacidas vivas o introducidas en la explotación durante los 3 meses anteriores a la encuesta).

Number of dairy heifer calves	<2 percent mortality		>10 percent mortality		total
	number	percent	number	percent	
3 to 16	721	85.3	124	14.7	845
17 or more	389	80.4	95	19.6	484
3 or more	1110	83.5	219	16.5	1329

unequal error variances across operations of various sizes (Maddala, 1988). Therefore, assigning operations to high and low scours mortality categories and performing logistic regression to identify factors associated with high scours mortality was the best that could be done with the data at hand. Performing the analysis two different ways and arriving at similar results served to validate the findings.

Although statistically significant associations between certain management practices and increased farm-level mortality due to scours were found, this does not necessarily mean that these management practices caused the increased mortality due to scours. The associations identified in this study suggest possible areas where attention by dairy producers and further research may be beneficial. Costs of measures taken to reduce scours mortality among preweaned dairy heifers would need to be considered in order to determine the net benefit that dairy producers would achieve by reducing scours mortality (Heady and Dillon, 1961).

This analysis did not take into account

the incidence of scours on the operations, other than when scours was identified as the leading or second-leading cause of death. We don't know whether the calves died suddenly, or after a period of time following the onset of disease. Scours is a symptom of disease, which may have a microbiologic basis influenced by management. A previous NDHEP report dealt with the presence of *Salmonella* sp. in the faeces of preweaned dairy heifers (Losinger *et al.*, 1995). No information was collected on how individual calves with scours were treated, nor on individual predisposing biological or environmental factors (such as lack of vitamins, or whether individual calves were treated differently from the rest of the herd). This was purely a herd-level analysis. Although information was collected on the number of calves that became ill with scours over the 3-month period, these data were not sufficiently reliable to warrant analysis. Different producers probably have different thresholds for discerning disease, and different levels of observing and monitoring the health of their calves. From the data, it was impossible to deter-

**Table V.** Results of stepwise logistic regression for risk factors of an operation having > 10 percent mortality (as compared to < 2 percent mortality) due to scours among preweaned dairy heifer calves. (Resultados de la regresión logística por etapas para los factores de riesgo de una explotación con más del 10 p. 100 de mortalidad (comparándolo con las de menos del 2 p. 100 de mortalidad) debida a la diarrea entre las terneras antes del destete).

Variable/ Response	Odds ratio	95 percent CI	p
Number of dairy heifer calves born alive or moved onto operation			
3 to 16	0.761	0.544 to 1.064	0.110
17 or more	1		
Region			
Midwest	0.597	0.386 to 0.919	0.019
Northeast	0.623	0.387 to 1.003	0.051
Southeast	0.531	0.319 to 0.885	0.015
West	1		
Rolling herd average milk production			
<7,258 kg	3.053	1.690 to 5.515	0.000
7,258 to 9,072 kg	2.280	1.297 to 4.008	0.004
>9,072 kg	1		
Grouping of preweaned heifers			
Not grouped	0.643	0.423 to 0.978	0.039
2-6 in group	0.545	0.317 to 0.935	0.028
>6 in group	1		
Sex of person primarily responsible for care of preweaned dairy heifers			
Male	1.652	1.139 to 2.353	0.005
Female	1		
Calves housed in individual hutches			
Yes	1.583	1.139 to 2.201	0.006
No	1		
Mean age of calves when first offered grain/other concentrated feeds			
≤6 days	0.610	0.436 to 0.853	0.004
>6 days	1		
Calves are fed fermented milk after colostrum			
Yes	0.699	0.515 to 0.949	0.022
No	1		

mine whether a producer had reported low levels of illness because he had paid little attention to his calves (and truly had

high morbidity in his herd) or because he had genuinely taken excellent care of his calves and had reported accurate disease



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levels. In any sample survey, a certain degree of nonsampling error is to be expected (Sukhatme and Sukhatme, 1970). It is likely that more producers knew with greater precision the number of calves that had died of scours than the number of calves that had been ill with scours during the 3-month period prior to interview.

Although the model showed no significant differences between herd sizes (as measured by the number of dairy heifer calves that had been born alive or had moved onto the operation in the 3 months prior to interview) in terms of the outcome variable, this does not mean that herd size was unrelated to death due to scours among preweaned heifers. The assignment of operations to high and low scour death categories differed by herd size. The goal of the categorization scheme was to have similar proportions of operations in the high scour death category across operation sizes to facilitate the evaluation of other variables relating to farm management. In the context of this analysis, herd size represents an extraneous source of variability (Montgomery, 1976). Previous surveys found that overall calf mortality increased (Hartman *et al.*, 1974; Oxender *et al.*, 1973) or decreased (Jenny *et al.*, 1981) with increasing herd size.

Regionally, dairy operations in the West had significantly higher odds of being in the high scour death level category than dairy operations in the Midwest and Northeast. The same finding was reported for overall mortality (Losinger and Heinrichs, 1997) and mortality due to respiratory diseases (Losinger and Heinrichs, 1996b). The West also had a greater number of larger

herds than the other regions of the country (table II).

Higher rolling herd average milk production was also found to be associated with decreased mortality overall (Losinger and Heinrichs, 1997) and mortality due to respiratory problems (Losinger and Heinrichs, 1996b). Management practices associated with milk production have been examined using data from the NDHEP and reported elsewhere (Losinger and Heinrichs, 1996a). Higher producing herds are more carefully managed than lower producing herds (Chase, 1993; Funk, 1993) and have animals of higher genetic potential (Funk, 1993). Management, as reflected in rolling herd average milk production, also seems to have a significant influence on mortality.

Associations between mortality and calf-rearing personnel have been reported by several researchers (Jenny *et al.*, 1981; Losinger and Heinrichs, 1997; Martin *et al.*, 1975; Waltner-Toews *et al.*, 1986). Hartman *et al.* (1974) reported lower calf mortality in operations where the producer's wife was chiefly responsible for taking care of the calves. The reasons why mortality due to scours was lower when a female took care of preweaned heifers were unknown, although quite significant.

Dairy operations that place preweaned calves together in large groups may need to pay more attention to the health of their calves, as disease transmission from calf to calf may be more rapid than when using other forms of housing. Waltner-Toews *et al.* (1986) reported increased calf mortality in operations that housed calves in group pens. Peters (1986) reported that calves housed indoors which

developed scours were more likely to die if they were group-penned than penned individually. Placing preweaned calves in groups of  $\geq 7$  was also found to be significantly associated with both mortality due to respiratory problems (Losinger and Heinrichs, 1996b) and mortality overall (Losinger and Heinrichs, 1997).

The finding that operations that housed preweaned heifers in individual hutches were more likely to be in the high scour death group than operations that utilized other methods of calf housing is perhaps surprising since group-rearing would be expected to facilitate the spread of enteric organisms (Peters, 1986), and since the result seems inconsistent with the finding that operations that placed preweaned heifers in large groups had increased mortality due to scours. Individual hutches are the most common form of housing for preweaned dairy heifers in the United States (USDA, 1993), and are generally recommended for young dairy calves (Heinrichs, 1993). Peters (1986) reported that individually reared calves had a higher incidence of scours than calves reared in groups, although, as mentioned above, calves housed indoors that developed scours were more likely to die if group-penned than if penned individually. More research is required to determine definitively the relationship between housing in individual hutches and mortality due to scours.

The composition of the diet of preweaned heifers can have a major impact on the incidence of scours and mortality (Heinrichs and Swartz, 1990; Roy, 1980). Neonatal feeding practices in the United States (based upon the

NDHEP) have been previously reported (Heinrichs *et al.*, 1995). Feeding starter grain as early as possible is generally recommended (Heinrichs and Swartz, 1990). Keys *et al.* (1979) and Roy (1980) recommended fermenting mastitic or antibiotic milk to make it possible to feed this milk to calves without causing health problems. The results of our study indicated that operations that fed starter grain to calves within the first 6 days of life and that fed fermented milk to preweaned calves had reduced mortality due to scours among preweaned dairy heifers.

## CONCLUSIONS

Scours was the principal producer-identified cause of morbidity and mortality among preweaned dairy heifers in the United States. Dairy operations in the West had higher mortality due to scours among preweaned dairy heifers than dairy operations in the rest of the country. Higher rolling herd average milk production was associated with decreased mortality due to scours among preweaned heifers. Preweaned dairy heifers were less likely to die of scours when a female was primarily responsible for taking care of them than when a male was primarily responsible for taking care of them. Placing preweaned calves in large groups and housing preweaned calves in individual hutches were both associated with increased mortality due to scours. Feeding starter grain within the first 6 days of life and feeding fermented milk were associated with lower scours mortality in preweaned dairy heifer calves.

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