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Management Factors Related to Calf Morbidity and Mortality Rates

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ABSTRACT

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An observational epidemiological study was carried out on 63 commercial Dutch dairy farms. The relationship between managerial procedures and morbidity and mortality patterns in 1037 dairy calves from birth to 4 months of age was investigated. Data on health disorders concerned dullness at birth, diarrhoea, navel disorder and respiratory disease. Relationships were quantified by relative risk estimation and trends were studied by using life tables for age groups and calendar months. Descriptive results largely reflect common management procedures and are comparable with other reported data. Several managerial factors were shown to have a significant influence, either increasing or decreasing, on the risk of occurrence of diarrhoea, respiratory disease and mortality. The impact of other variables remains uncertain, pointing to the need for further studies. The application of epidemiological methods could be a powerful tool to quantify the risk associations between disease state and animal, herd, management or environmental factors. Veterinary-zootechnical programmes for herd health and production control could be further improved in that way.

INTRODUCTION

Herd Health and Production Control programmes for dairy farms usually include factors such as nutrition, milk production, udder health, reproduction and farm economics (Blood et al., 1978; Noordhuizen et al., 1982, 1983). Young stock rearing is a separate entity on the farm, where aspects such as nutrition, health, reproduction, growth, housing and management are involved in a complex way (Renkema and Stelwagen, 1979; Roy, 1980). Little is known about the quantitative impact of possible risk factors at the farm, herd and individual

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levels on the health of replacement animals. Recent observational–analytical studies have dealt with this problem to a certain extent (Waltner-Toews et al., 1986a,b,c,d; Curtis et al., 1988a,b). Epidemiological studies may reveal the various risk factors involved in young stock rearing, especially since the determination of risk factors is focussed on causality in addition to statistically significant associations and interactions. One of the parameters in such studies is the Relative Risk (Martin et al., 1987), representing the strength of association between a factor and a disease. It is calculated as the ratio between the disease rate in exposed and non-exposed animals.

The objectives of the current study on commercial Dutch dairy farms were: (1) to detect patterns of morbidity and mortality in young stock up to 4 months of age; (2) to determine the relationships between morbidity and mortality and calf-rearing practices.

MATERIAL AND METHODS

Population under study

Information about calf-management practices was collected on 63 commercial Dutch dairy farms in the Ambulatory Clinic area of the Veterinary Faculty, State University of Utrecht. Herds could be selected when they had between 40 and 70 milking cows, when milk production was recorded by the national milk recording service (NRS) and when farmers were accustomed to record keeping. General characteristics (mean values) of the herds under study are: 53 milking cows; 25.4 ha grassland; 5833 kg milk per cow; 15 years of farming experience. Sixty one percent had loose housing and 39% a stanchion barn.

Data collection

Data collection started on 1 January 1986 and ended on 1 April 1987, when the last-born calf had reached the age of 4 months. All farms were visited twice weekly by senior students from agricultural colleges under the supervision of veterinarians from the Department of Herd Health and Ambulatory Clinic in Utrecht. Daily farm events (calf number, birth date, body weight, disease, treatment, sale, death) were recorded on an individual calf sheet. At each farm visit the animals were inspected for clinical disease. At the same time, management information such as birth history, colostrum practice, feeding procedure, preventive measures and data on housing was collected. Each calf was given this intensive follow-up either until the age of 4 months or until it left the farm (sale or death). The calves were girth measured or weighed at the first visit after birth, once weekly for 5 weeks, 1 week after weaning and at the third and fourth month of age.

Variables in the data set

The variables in the data set regarding calves, herds and farms, used for the analysis are given in Table 1. Two periods are considered: from birth to first day of life, and from Day 1 to 4 months of life.

Data on clinical disease refer to dullness at birth, diarrhoea, navel disorders, respiratory disease and others. Disease state or symptoms were defined as follows. (1) Dullness: listless, without appetite, ears dropping, lack of activity according to the farmer's opinion. (2) Diarrhoea: watery faeces, occasionally with undigested milk particles or blood. Faeces well formed, pasty or soft-pasty were considered to be normal. (3) Navel disorders: swollen umbilical cord, wet, with or without pus. (4) Respiratory disease: increase in respiratory rate together with coughing, body temperature above 39.5 °C, with or without discharge from eyes and/or nose. (5) Other diseases: all muscular-skeletal injuries, arthritis, periarthritis and diphtheria.

Season classes were defined as "indoors" and "outdoors", referring to the periods from either 1 January to 29 April 1986 or 20 October to 31 December 1986, and 30 April to 20 October 1986.

Data storage and validation

All calf data were stored in files per farm using a fixed-format computer file of the editor program of Olivetti (Ivrea, Italy). At the end of the field survey all files were read with Micronetics Standard MUMPS (MSM, Micronetics, MD) to check the integrity of the data. All errors caused by deficient data input were corrected using the original field survey sheets. Finally, one large data set was created containing all the data pertaining to the calves born in the 63 herds.

Data analysis

The original data set was split into two parts: one subset with calves that were retained in the herds and a second with calves sold. In this analysis only the first subset is handled. Data were analysed on the individual calf level, not on the herd or cluster level.

Statistical analyses were performed by using SAS procedures (SAS, 1985). Descriptive results were obtained by using the PROC FREQ procedure. Life tables were plotted as proportions of disease or death. That is, for each time period the new cases were expressed as a proportion of the number of calves-at-risk (incidence rates). The same procedure was handled for seasonal patterns, except for the month of occurrence as time period. The denominator (population-at-risk) was estimated by summing up the number of calves alive

TABLE 1

Description and frequencies of calf-management variables related to individual calves ($n = 1037$) in 63 dairy herds in The Netherlands (1986-1987)

From birth to first day of life			From 1 day to 4 months of life		
Variable	Description	%	Variable	Description	%
Breed of calf	Pure	17.1	Type of milk	Milk replacer	25.8
	Cross	82.9		Cow's milk	74.2
Sex of calf	Male	11.4	Quantity of milk	2-5 l day^{-1}	63.9
	Female	88.6		> 5 l day^{-1}	36.1
Birth season	Indoor	67.2	Times per day milk fed	Twice	82.9
	Outdoor	32.8		> Twice	17.1
Parity of the dam	First	21.2	Feeding method	Bucket	68.7
	Older	78.7		Teat bucket	30.3
Calving history	Normal	85.8	Second housing	Indoors	90.5
	Abnormal[1]	14.2		Out/open front	9.5
Calving area	Calving pen	42.0	Housing type	Single	17.7
	Other[2]	58.0		Group	82.3
Navel treated	Yes	55.8	Heating lamp	Yes	2.3
	No	44.2		No	97.7
First calf housing	Calf barn	19.6	Air ventilation	Natural	89.9
	Other[3]	80.4		Mechanical	10.1
Housing type	Single	56.6	Ventilation channel	Low wall	11.9
	Group	43.4		High wall, roof	88.1
Colostrum source	Own dam	98.7	Floor type	Concrete, straw	58.0
	Nursing cow	1.3		Woods slats, straw	42.0
Diseased dam peripartum	Yes[4]	19.3	Environment inspection	As standard	35.5
	No	80.7		Other	64.5
Age first colostrum	First 3 h	78.3	Cleanness	100% = good	16.9
	> 3 h	21.7		Other = poor	83.1
Colostrum feeding	Dam suckled	14.3	Bedding changed	Daily	15.2
	By hand	85.7		Irregular	84.8
Quantity first colostrum intake	< 2 l	31.9	Artificial light	Yes	31.8
	> = 2 l	68.1		No	68.2
Days feeding colostrum	1 day	2.6			
	2-4 days	97.4			
Quantity first day colostrum	1-8 l	80.8			
	Unknown	19.2			

[1]Obstetric manipulation and Caesarean section (dystocia).
[2]Stanchion, outdoors, loose barn.
[3]Other areas where adult cattle are present.
[4]Milk fever, mastitis, retained placenta, combinations.

and non-diseased at the end of 1 month and the number of calves born the next month.

The CATMOD procedure was used for building a logistic regression on dichotomously scaled responses with two levels, such as diseased vs. non-diseased state. This technique is used in many epidemiological analyses (Martin et al., 1987). Multiple backward logistic regressions were performed. Each variable was examined at each step and if a change in its level of significance occurred, in comparison with the previous model, interactions within the variables dropped were tested. The time sequence between potential risk factors (individual calf-management practices) and the outcome variable (disease event) was tested using PROC FREQ. The outcome variables tested were the first and second case of diarrhoea and respiratory disease in addition to cases of mortality. Estimations of Relative Risk were performed according to the methods presented by Martin et al. (1987).

RESULTS AND DISCUSSION

Descriptive results

During the period of study, 3061 calves were born. The farmers retained 1037 calves (88.6% female, 11.4% male) in the herds. Almost all male calves and dairy × beef cross-bred calves had been sold in the first weeks after birth. The breed distribution was as follows: 70.6% Dutch Friesian (DF) × Holstein (HF); 8% HF; 5.8% Meuse-Rhine-IJssel (MRIJ); 3.3% DF; 2% MRIJ × DF; 1.1% MRIJ × HF; 0.4% DF × red HF and 8.8% dairy × beef cross breed. Based on heart girth measurements, the average weight at birth was 40.5 ± 5.6 kg. The average daily weight gain in the first month of age was 450 g and in the first 4 months 620 g. Of all calves born, 67.2% were born during the indoor season and 32.8% during the outdoor season.

A description of calf-management variables and their frequencies in the 63 herds is presented in Table 1.

The crude morbidity rate for diarrhoea was 24.6% in female and 19.8% in male calves. Other studies indicated a 20% rate between birth and weaning (Waltner-Toews et al., 1986a) and a 9.9% rate between birth and 14 days of age (Curtis et al., 1988a).

The incidence rate for respiratory disease was 5.8% for female and 0.9% for male calves, in this study. These figures are low when compared with results from studies in the U.S.A. (7.4%) and Canada (15%), both quoted above.

The respective rates for navel disorders and dullness were 4.3% and 3.6%, and 0.5% and 2.7% for female and male calves. There were too few cases of dullness to perform a further analysis.

The mortality rate was 4.9% in female and 21.6% in male calves. The mortality rate for female calves is comparable to the 3.8% reported in the Canadian study and the 3.5% in the U.S.A. study. The mortality rate for male calves is rather high though other studies report comparable figures varying from 17.7%

(Oxender et al., 1973) to a range between 3.5% and 30.6% (Martin et al., 1975a,b).

Life tables

Morbidity and mortality rates in relation to a time component are important features of epidemiological studies since they may help in finding seasonal patterns or trends of changes in management practices between seasons. Two major factors have been considered in the current study: the age as a host factor and the calendar time. The proportions of calves-at-risk that died, showed dullness, diarrhoea, navel disorder or respiratory disease are presented in Table 2 (per month) and Table 3 (per age class). A comparison of mortality rates over seasons did not yield any statistically significant difference ($P > 0.20$), a result similar to those of Waltner-Toews et al. (1986b) and Curtis et al. (1988a). The incidence rates for diarrhoea and respiratory disease in female calves were significantly higher ($P < 0.01$) during the indoor season than the outdoor season, again a result similar to those of the authors quoted above. The male calves appeared to be at a significantly higher risk for diarrhoea only during the indoor season ($P < 0.01$).

Regarding the age of the calf, the highest risk of mortality occurred during the first 3 weeks and decreased with increasing age (Table 3). It dropped from 2.3% in the first week to 0.9% in the third week in females. From the fourth week onwards, mortality was low for both sexes. This pattern has been re-

TABLE 2

Life table for first cases of disease and mortality in individual heifer calves between 0 and 4 months of age on 63 commercial Dutch dairy farms (1986–1987). Data expressed by calendar month (n = number of calves)

Month	Born	At-risk, morbidity	At-risk, mortality	Dull	Diarrhoea	Navel disorder	Respiratory disease	Death
1	96	96	96	0.010 (1)	0.34 (33)	0.041 (4)	0.052 (5)	0.02 (2)
2	111	161	205	0 (0)	0.17 (28)	0.024 (4)	0.049 (8)	0.024 (5)
3	131	194	331	0 (0)	0.23 (45)	0.025 (5)	0.020 (4)	0.018 (6)
4	102	171	331	0.005 (1)	0.18 (31)	0.017 (3)	0.005 (1)	0.021 (7)
5	66	124	279	0 (0)	0.13 (17)	0.048 (6)	0.016 (2)	0.035 (10)
6	45	74	183	0.013 (1)	0.16 (12)	0.054 (4)	0.027 (2)	0.010 (2)
7	32	55	111	0 (0)	0.14 (8)	0.054 (3)	0 (0)	0.009 (1)
8	34	52	78	0.019 (1)	0.05 (3)	0.019 (1)	0.019 (1)	0.025 (2)
9	44	70	75	0 (0)	0.10 (7)	0 (0)	0.042 (3)	0.013 (1)
10	52	83	94	0 (0)	0.08 (7)	0.024 (2)	0.120 (10)	0.021 (2)
11	57	83	115	0 (0)	0.12 (10)	0.024 (2)	0.072 (6)	0.008 (1)
12	88	126	158	0 (0)	0.12 (16)	0.023 (3)	0.071 (9)	0.012 (2)

TABLE 3

Life table for first cases of disease and mortality in individual heifer calves between 0 and 4 months of age on 63 commercial Dutch dairy farms (1986–1987). Data expressed by age intervals of 7 days (n = number of calves)

Last day of interval	At-risk morbidity	At-risk mortality	Dull	Diarrhoea	Navel disorder	Respiratory disease	Death
7	859	859	0.0046 (4)	0.10 (92)	0.022 (19)	0.001 (1)	0.023 (20)
14	717	839	0 (0)	0.10 (74)	0.012 (8)	0.003 (2)	0.009 (8)
21	622	831	0 (0)	0.04 (26)	0.006 (3)	0.006 (3)	0.002 (2)
28	581	829	0 (0)	0.02 (12)	0.009 (4)	0.018 (8)	0.002 (2)
35	547	827	0 (0)	0.01 (7)	0.005 (2)	0.020 (8)	0.003 (3)
42	521	824	0 (0)	0.001 (1)	0.002 (1)	0.013 (5)	0.004 (4)
49	507	820	0 (0)	0 (0)	0 (0)	0.005 (2)	0.001 (1)
56	504	819	0 (0)	0 (0)	0 (0)	0.002 (1)	0.002 (2)
63	500	817	0 (0)	0 (0)	0 (0)	0.002 (1)	0 (0)
70	498	817	0 (0)	0 (0)	0 (0)	0.003 (1)	0 (0)
77	496	817	0 (0)	0 (0)	0 (0)	0.003 (1)	0 (0)
84	494	817	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
91	494	817	0 (0)	0 (0)	0 (0)	0.003 (1)	0 (0)
98	492	817	0 (0)	0 (0)	0 (0)	0.009 (3)	0 (0)
105	489	817	0 (0)	0 (0)	0 (0)	0.006 (2)	0 (0)
112	486	817	0 (0)	0 (0)	0 (0)	0.012 (4)	0 (0)
119	482	817	0 (0)	0 (0)	0 (0)	0.009 (3)	0 (0)
126	479	817	0 (0)	0 (0)	0 (0)	0.006 (2)	0 (0)
133	477	817	0 (0)	0 (0)	0 (0)	0.004 (2)	0 (0)

ported in the literature (Leech et al., 1968; Martin et al., 1975a; Waltner-Toews et al., 1986b; Curtis et al., 1988a).

The case fatality rate, defined as the number of calves with a disease which died, divided by the number of cases of the given disease, was highest for diarrhoea (52%) followed by navel disorders and other non-defined diseases (36%), and by respiratory disease (12%).

The peak age for diarrhoea occurred in the first 2 weeks but dropped dramatically to levels near zero from Day 30 of life for female and from Day 29 for male calves. This finding is in agreement with the literature (Martin et al., 1975a,b; Roy, 1980; Saif and Smith, 1985; Waltner-Toews et al., 1986b,c; Curtis et al., 1988a). The age pattern for respiratory disease in calves older than 1 month also appeared to be similar to those reported earlier (Martin et al., 1975a,b; Roy, 1980; Waltner-Toews et al., 1986b). Only Curtis et al. (1988a,b) reported higher rates during the first week of life, though diagnosis was made by the farmer in their study, and differences may occur owing to failures in colostral immunity transfer from dam to calf (Postema and Mol, 1984). The respiratory disease pattern showed a peak at 30 days of age for both sexes and decreased from 40 days onwards to sporadic occurrences in female calves.

Management variables related to morbidity and mortality

General remarks

The calving area, dystocia rate and the source of colostrum had no significant effect on morbidity and mortality rates. Other authors found calving area, other than a pen, to be a risk factor for both diarrhoea and death (Waltner-Toews et al., 1986c,d; Curtis et al., 1988b). This difference could be explained by the fact that at least 85% of all calves in our study have been hand-fed and 78% have been assisted in colostrum intake during the first 3 h of life, meaning that a close and early attendance could result in good passive immunity. The latter could also be more important than the pen itself. In this study, the risk of dystocia appeared to be lower in first parity dams compared with older parity dams. This may be explained by good management practice; choosing easy-calving sires for maiden heifers.

Diarrhoea

Risk factors for the development of diarrhoea (Table 4) appeared to be: outdoor season (from 30 April to 19 October), first parity of the dam, colostrum feeding during 1 day only, poor climatic conditions (draught, foal smell, humid), group housing of calves and irregular changing of bedding materials. In addition, a first case of diarrhoea increased the risk of a repeated case. The other variables tested (Table 1) did not yield a significantly increased risk. Milk replacer feeding method (teat bucket), poor cleaning practices and roughage intake appeared to be protective against diarrhoea.

Regarding season, a higher risk of diarrhoea was found for the calves born during the outdoor season; that is from 30 April to 20 October.

Although first parity is a risk factor, it must be noted that the confidence interval contains the value of 1 for relative risk, meaning that there is an association of risk, but possible sampling errors or insufficient sample size have occurred. Colostrum from first parity dams could contain less immunoglobulins than that from older herd-mates (LeBlanc, 1981), thus facilitating the colonisation of the gut by coliform bacteria causing diarrhoea. However, in a Dutch survey no differences in immunoglobulin concentrations between parities were found (Postema and Mol, 1984). The majority of calves in our study (68%) received at least 2 l colostrum at first intake. Van Keulen et al. (1984) showed that a first intake of at least 1.5 l resulted in good serum-immunoglobulin levels in calves in the same area. In this study, a negative effect of first parity on diarrhoea occurrence could not be detected.

Colostrum feeding during 1 day instead of more may decrease the total immunoglobulin intake of the calf and thus the specific resistance against enteric infections (Saif and Smith, 1985).

Housing in group pens appeared to represent a higher risk than single housing, which may be a matter of infection build up. First housing place was not

TABLE 4

The estimated significant Relative Risk factors from calf-management practices affecting individual calves for diarrhoea and respiratory disease on 63 commercial Dutch dairy farms. See text for a full description of variables

Diarrhoea			Respiratory disease		
Variable description	Relative Risk	C.I. 95%	Variable description	Relative Risk	C.I. 95%
Season			Navel treated	1	
Indoor 1	1		Not treated	2.45	1.36–4.42
Outdoor	1.62*	1.09–2.39	Parity		
Parity			>1	1	
>1	1		=1	0.55*	0.29–1.03
=1	1.56	0.99–2.44	Milk quantity		
Colostrum fed			<5	1	
>1 day	1		>5 l day^{-1}	1.91	1.06–3.44
1 day	2.86*	2.36–7.15	Bedding		
Bucket feeding	1		changed daily	1	
Teat bucket	0.65	0.44–0.96	irregular	0.38	0.19–0.74
Single housed	1		No artificial light	1	
Group housed	2.13	1.28–3.55	With light	2.03	1.13–3.59
Good climate	1		Cross breeds	1	
Poor climate	1.61	1.11–2.34	Pure breeds	0.47	0.23–0.98
Good cleaning	1				
Poor cleaning	0.51*	0.24–1.05			
No added roughage	1				
With roughage	0.71	0.51–0.99			
Bedding change	1				
Irregular	2.27	2.74–5.07			

C.I. 95% = lower and upper limits of the 95% confidence interval.
* = $P<0.10$; all other values are significant at the $P<0.05$ level.
Examples of interpretation of the Relative Risk (RR):
RR = 1 means there is no association between factor and disease, excluding variation owing to sampling error.
RR > 1, means the more deviating from 1, the stronger the association between factor and disease.
RR = 2.13 for group housing means that calves first housed in group pens incur a 2.13 higher risk of getting diarrhoea compared with calves first housed in individual boxes.
RR = 0.47 for pure breeds means that pure-bred calves incur a much lower risk for getting respiratory disease than cross breeds. The confidence interval indicates the accuracy of the result. If this interval includes the value 1, then there is an association of risk but possibly sampling errors or insufficient sampling size have occurred.

a relevant factor, possibly owing to the fact that in our study farmers usually remove the calves from the calving area within 3 days, avoiding crowding and allowing proper nursing. Goodger and Theodore (1986) reported similar results.

Teat bucket feeding of replacer milk showed a lower risk of diarrhoea than

TABLE 5

The Relative Risk values for repeated case of disease after a previous disease event on 63 commercial Dutch dairy farms (1986–1987). See legends to Table 4 for explanation of Relative Risk

Variable	Description	Relative Risk (C.I. 95%)
	Diarrhoea previously	
Repeated diarrhoea	No	1
	Yes	3.31* (1.75–6.16)
	Diarrhoea previously	
Repeated respiratory disease	No	1
	Yes	3.79* (2.10–6.52)
	Previous respiratory disease	
Repeated respiratory disease	No	
	Yes	Not significant

C.I. 95% = lower and upper limits of the 95% confidence interval.
*$P < 0.001$ significance level.

other methods. No associations were found between whole cow milk or replacer milk feeding and incidence of diarrhoea. Waltner-Toews et al. (1986c) reported an increased risk of diarrhoea after replacer milk feeding. These differences could be explained by aspects such as preparation failures or quality aspects.

Additional roughage feeding was a protective factor against diarrhoea, which possibly reflects the early rumen development in these calves reducing the incidence of diarrhoea (Roy, 1980). No effect of additional concentrate feeding nor drinking water was found.

Calves exposed to poor climatic conditions such as draught, humidity and foal smell had a higher risk of diarrhoea. Irregular changing of bedding material also increased the risk. A dynamic balance between infection pressure and immune status, as well as the hypothesis that daily bedding changing may lead to effective aerosolisation of inhalable pathogens could be an explanation for this finding. Poor cleaning practices seem to be protective against diarrhoea, though the confidence interval contains the value of 1 for Relative Risk. This means that there is a risk association, but possibly sampling errors have occurred.

The risk of a second diarrhoea case (Table 5) was higher in calves with a previous case, a finding also reported by Waltner-Toews et al. (1986c) and Curtis et al. (1988b).

Respiratory disease

The risk factors (Table 4) were: no navel treatment, daily quantity of milk replacer fed above 5 l, additional artificial light, previous case of diarrhoea (Table 5). Protective factors were: first parity of the dam, irregular changing of bedding material, pure breed. The other variables (Table 1) did not have any significant effect. Not treating the navel at birth was a risk factor. Since the median age of respiratory disease is 40 days, possibly something else was measured indirectly, such as care for the calf. At the age of 40 days the calf is supposed to develop its own active immune system and to deal with agents affecting health status.

Although navel disinfection is generally recommended, its beneficial effect has still to be proved (Goodger and Theodore, 1986).

The effects of outdoor, indoor or open-front housing were not significant, nor was the first housing place. Together with the diarrhoea risk this leaves the total effect of group housing on health still unclear. Curtis et al. (1988a) found group housing a risk factor for respiratory disease, depending on season. The calves fed more than 5 l milk daily had a greater risk of respiratory disease. With an average age at this disease of 40 days and body weight of 60 kg this quantity is in accordance with general feeding guidelines (Roy, 1980). No interaction was found between quantity of milk fed and feeding method, reducing the possibility of increased risk of pneumonia by milk aspiration.

A higher risk was found when bedding materials were changed daily instead of infrequently, raising the hypothesis that effective aerosolisation and inhalation of pathogens may occur in this way.

Respiratory disease incidence was also higher in calves with a previous case of diarrhoea, but not with a previous case of respiratory disease. Similar findings have been reported (Waltner-Toews et al., 1986c; Curtis et al., 1988b).

Additional artificial light was a risk factor, though it is not clear through which mechanisms it acts.

First parity was a protective factor against respiratory disease which may reflect the active immune system developed earlier in calves from these dams. In this case the confidence interval also has a value of 1 for Relative Risk.

The fact that pure-bred calves had a lower risk for developing respiratory disease than cross breeds may reflect the results of a long-term breeding policy rather than a sensibility in cross-bred calves.

Mortality

Risk factors were: previous case of diarrhoea; periparturient disease of the dam; sex of the calf. Protective factors were: first parity; group housing; quantity of milk fed daily above 5 l; additional roughage intake (Table 6).

The median age of diarrhoea occurrence is 8 days. Though no diagnostic testing on pathogens was performed it seems most likely that *Escherichia coli* could be involved in those cases. It is well known that mortality may occur after such infections (Roy, 1980).

Diagnostic testing was not performed in cases of respiratory disease either, but it seems most likely that common bacteria were involved in those cases and not viral infections.

Calves from dams with periparturient disease showed a higher risk of death

TABLE 6

Relative Risk values for mortality in individual calves. Data from 63 commercial Dutch dairy farms (1986–1987). See legends to Table 4 for explanation of Relative Risk

Variable description	Relative Risk	C.I. 95%
Dam's parity		
>1		
$=1$	0.45	0.23–0.94**
First housing		
Single		
In group	0.39	0.18–0.86**
Dam's disease		
No		
Yes	2.33	1.11–4.92**
Total milk		
<5 l day^{-1}		
>5 l day^{-1}	0.17	0.067–0.47**
Additional roughage		
No		
Yes	0.27	0.12–0.61**
Diarrhoea		
No		
Yes	2.91	1.43–5.90**
Sex of the calf		
Female		
Male	2.03	0.85–1.57*

C.I. 95% = lower and upper limits of the 95% confidence interval.
* = $P<0.10$.
** = $P<0.05$.

than calves from non-diseased dams. This may possibly be explained by the low colostral immunoglobulin content in the diseased cows (e.g. mastitis or milk fever).

Male calves appeared to incur a higher risk of mortality than female calves, though the association is weak. The confidence interval shows a value of 1 for Relative Risk, meaning that possibly sampling errors have occurred.

The finding that first parity is a protective factor for mortality but a risk factor for diarrhoea remains unclear. Possibly, the age of the calf and thus immune status, both passive and active, are involved in this phenomenon. Dystocia rate was lower in these dams too, resulting in a lower chance of mortality.

Group housing resulted in a lower mortality rate than single housing, though the diarrhoea incidence was higher. A more optimal visual control of calves in group housing, especially regarding health and behaviour, are possible reasons.

On the other hand it must be stated that diarrhoea involves passive immunity and disease around 4–5 weeks of age rather than the active immune system of the calf.

Quantity of milk fed above 5 l daily was a protective factor. Malnutrition could cause immuno-incompetence in neonatal calves, and it seems biologically plausible that suboptimal protein supply will not support an optimal immune response in calves fed less than 5 l day^{-1} (Table 6). Roughage intake was another protective factor in this study, indicating the possible positive effect of early rumen development on general health status in young dairy calves (Roy, 1980). Further study is needed to elucidate the relationship between nutrition and the health aspects mentioned here.

CONCLUDING REMARKS

The objectives of this study have only been partly achieved. The relationships of morbidity and mortality with individual calf and management variables have not been fully elucidated. Other studies, such as cohort, case-control and experimental design, are needed for a further elaboration of these relationships. Since management has a rather abstract meaning, is complex in nature and its impact is difficult to quantify, the application of epidemiological methods such as logistic regression and Relative Risk estimation may contribute to a better understanding of disease and disease patterns. Additionally, the risk quantification might support the setting of priorities and fields of attention in herd health and production-control programmes.

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RESUME

Perez, E., Noordhuizen, J.P.T.M., van Wuijkhuise, L.A. et Stassen, E.N., 1990. Relations entre la morbidité et la mortalité des veaux et leur ménagement. *Livest. Prod. Sci.*, 25: 79-93 (en anglais).

Des observations épidémiologiques ont été effectuées dans 63 fermes laitières des Pays-Bas. Elles concernaient les relations entre les techniques de ménagement et la morbidité et la mortalité de 1037 veaux laitiers de la naissance à l'âge de 4 mois. Les troubles enregistrés étaient le manque de vitalité à la naissance, les diarrhées, les infections ombilicales et les troubles respiratoires. Les relations ont été quantifiées par l'estimation du risque relatif et les tendances étudiées à l'aide des tables de vie par groupe d'âge et mois calendaire. Les résultats montrent des techniques de conduite courantes et sont comparables aux données publiées. Plusieurs facteurs du ménagement ont une influence significative sur les risques de diarrhées, de troubles respiratoires et de mortalité. L'influence des autres variables reste incertaine, ce qui montre la nécessité de nouvelles études. L'application des méthodes épidémiologiques pourrait être un puissant outil pour quantifier les risques de maladie à partir des facteurs liés à l'animal, au troupeau, à la conduite ou au milieu. Elle permettrait d'améliorer les programmes pour maîtriser la santé et la production des troupeaux.

KURZFASSUNG

Perez, E., Noordhuizen, J.P.T.M., van Wuijkhuise, L.A. und Stassen, E.N., 1990. Beziehungen zwischen Haltungsfaktoren und Krankheits- und Sterblichkeitsrate von Kälbern.. *Livest. Prod. Sci.*, 25: 79-93 (auf englisch).

Eine beobachtende epidemologische Studie wurde auf 63 holländischen Milchbetrieben durchgeführt. Die Untersuchung galt den Beziehungen zwischen den Haltungs- und Aufzuchtverfahren und dem Krankheits- und Sterbeverhalten von 1037 Kälbern einer Milchrasse von der Geburt bis zum 4. Lebensmonat. Die Daten der Gesundheitsprobleme bezogen sich auf Lebensschwäche bei der Geburt, Durchfall, Nabelentzündungen und Krankheiten der Atemwege. Die Beziehungen wurden durch relative Risikoschätzungen ermittelt, und Trends wurden jeweils mit Hilfe von Lebenstabellen für die Altergruppen und für Kalendermonate geschätzt. Beschreibende Ergebnisse spiegeln im Wesentlichen allgemeine Haltungsbedingungen wider und sind mit anderen beschriebenen Ergebnissen vergleichbar. Einige Haltungsfaktoren wurden als signifikante Einflüsse erkannt, die das Risiko eines Auftretens von Durchfall, Atemwegserkrankungen und Tod erhöhen oder erniedrigen. Der Einfluß anderer Faktoren bleibt ungewiß, was die Notwendigkeit weiterer Untersuchungen verdeutlicht. Die Anwendung epidemologischer Methoden können ein wertvolles Mittel sein, um die Beziehungen zwischen Krankeitsstatus und Tier, Herde, Haltungs- oder Umweltfaktoren zu bestimmen. Tiermedizinische Programme zur Herdengesundheit und Produktionskontrolle können auf diesem Wege weiter verbessert werden.