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Assessing the welfare of dairy calves: outcome-based measures of calf health versus input-based measures of the use of risky management practices

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Abstract

The mortality and morbidity of unweaned dairy calves and management practices that may impair calf health and welfare were surveyed on 115 farms in Canada (Quebec) and 60 farms in Central Europe (Austria and Germany) to examine whether outcome-based measures of calf health could be used to identify farms that use management practices that place calf health at risk. Quebec herds had higher juvenile mortality incidence than those in Central Europe. Juvenile mortality was poorly estimated by producers. Low levels of mortality did not include low levels of morbidity in the same herds. Health status was not necessarily associated with management practices generally recommended for health and welfare. Many management practices that may impair calf health and welfare were found in Quebec while only some were found in Central Europe; these were related to calving management and care of the newborn, colostrum management, calf-dam separation, calf feeding, weaning and calf housing. Inadequate recording of calf morbidity and mortality can be a problem in using recorded measures to assess the level of calf health on a farm. The recorded mortality and morbidity do not necessarily show the extent that producers use management practices that pose a risk to calf health.

Keywords: *animal welfare, dairy calves, health, management, on-farm assessment, producers' attitude*

Introduction

The criteria for assessing animal welfare are conventionally divided into input-based criteria, which describe the environment of the animal or the management practices used, and outcome- or animal-based criteria, which describe the actual state of the animal (Rushen *et al* 2008; Knierim & Winckler 2009). Most animal welfare standards rely on input-based measures but there has been increased interest in using more outcome-based measures, which were promoted as a central part of the Welfare Quality® Project (Knierim & Winckler 2009; Blokhuis *et al* 2010). One advantage of outcome-based measures is that they can be used to compare the welfare of animals housed in very different types of housing systems. Consequently, the use of outcome-based welfare criteria is promoted by the World Animal Health Organisation (OIE) as the basis for internationally harmonised animal welfare standards (OIE 2008) that allow different regions of the world to be judged according to the same animal welfare outcomes.

However, a complementary approach to assessing welfare, which is currently being developed, involves a formal risk analysis (Ribo & Serratosa 2009) that relies on input-based criteria that have been identified as the main risk factors for poor welfare (Rushen & de Passillé 2009). One advantage of input-based criteria is that they are often easier and quicker to audit (eg Knierim & Winckler 2009; Vasseur *et al* 2010b). The relative advantage of input-based and outcome-based welfare assessment criteria, and how best to combine them to get an overall welfare assessment, remains an unresolved issue (Rushen & de Passillé 2009).

Good health is an obviously important aspect of good welfare and the incidence of disease or mortality is a relatively uncontroversial outcome-based measure of poor health (Blokhuis *et al* 2010). Often, records are kept of animal disease, and there is some evidence that national animal-health databases may provide an initial screening method to identify farms with poor welfare (Sandgren *et al* 2009). Poor health is an important welfare concern for unweaned dairy calves (Rushen *et al* 2008), but despite the financial costs of rearing calves (Pellerin & Gilbert 2008) and the long-term effects on the future dairy cows (eg Shamay *et al* 2005), unweaned calf mortality and morbidity

remain high in North America (USDA 2008). However, there is evidence that dairy calf health is better in some parts of Europe (Svensson *et al* 2006; Gulliksen *et al* 2009a).

Welfare standards for dairy cattle often use the types of management practices that protect calf health as input-based welfare criteria (eg Dairy Farmers of Canada 2009). However, a recent survey of calf rearing in Quebec found that dairy producers continue to use management practices that place calf health at risk (Vasseur *et al* 2010a). These include infrequent use of a dedicated calving pen, infrequent surveillance of calvings, relying on unsupervised suckling as a source of colostrum, delaying and providing insufficient quantities of colostrum, not checking immunoglobulin quality and immunity transfer, and giving unpasteurised waste milk. We asked the question: to what extent can records of calf health be used to assess the use of such risky management practices on a farm? We also examined whether records of mortality and morbidity of unweaned dairy calves could be used to identify differences between international regions in the use of management practices that place calf health at risk.

Materials and methods

Selection and description of herds

We surveyed calf rearing methods and obtained estimates of pre-weaning calf mortality and morbidity from 115 dairy farms in Quebec between 2005 and 2007 and 60 dairy farms in Central Europe (30 in Austria and 30 in Germany) during 2007. Quebec farms were selected to be representative of farms in Quebec in terms of size (mean [± SD]: 52.5 [± 20.9] cows), milk production (8,697 [± 1,153] kg per cow per year), breed (Holstein) and housing method (tie-stalls) and were distributed throughout the province (Vasseur *et al* 2010a). The farms were selected on the basis of membership in Valacta Inc (Sainte-Anne-de-Bellevue, QC), which is the Dairy Herd Analysis System for Quebec and Atlantic provinces. Dairy farms in Austria and Germany were selected as part of the Welfare Quality® project aiming at the development of a welfare monitoring system for dairy cows (Winckler *et al* 2008), and reflected a typical range of husbandry systems in Central Germany (size: 43.2 [± 23.0] cows; milk production: 8,698 [± 856] kg per cow per year; main breed: Holstein Friesian) and Austria (size: 36.0 [± 26.7] cows; milk production: no data; main breed: Simmental). They differed widely in production systems (organic and conventional and productions levels, housing systems [tie-stalls, cubicles, and straw-yard systems]) and breeds (milk purpose breed: eg Holstein Friesian; dual-purpose breed: eg Simmental).

Collection and description of data

Interview and questionnaire

The on-farm surveys, which included a face-to-face interview with the farm manager, were carried out by a trained Valacta agent in Quebec, who was the regular farm advisor, and by trained observers in Central Europe (two in Germany, two in Austria), using a standard questionnaire, which consisted of multiple-choice and semi-closed questions, described in detail in Vasseur *et al* (2010a). The questionnaire was divided into seven categories of management practices that could affect calf welfare (Tables 1 and 2): calving management and care of the newborn, colostrum management, calf-dam separation, painful procedures, calf feeding, weaning, and calf housing. The answers to the questions (data) were qualitative nominal (eg Yes/No), qualitative ordinal (eg scale of answers from 1: Never, to 5: Always), or continuous (eg number of litres of colostrum). Dichotomous variables (1 vs 2) were generated from qualitative data, categorised as either risk or non-risky management practice for calf health, based on Vasseur *et al* (2010a).

Mortality and morbidity records

We collected data on unweaned calf mortality and morbidity. In Central Europe, incidences of mortality and morbidity for unweaned female calves of 4 categories of diseases (enteric, respiratory, navel, others) were collected at the farm (n = 58 herds), from producers' records when available. The annual incidence of mortality was expressed as the number of calves that died before weaning per year divided by the number of calves born (including calves born dead). The annual incidence of morbidity was calculated as the incidence of diseases before weaning per 100 calves born alive. Age at weaning was different for each farm (mean [± SEM], 10.8 [± 0.4] weeks for Central Europe herds, 7.2 [± 0.4] weeks for Quebec herds).

For Quebec, we obtained data on mortality during the first week of life (including calves born dead) from the Valacta database (n = 80 herds). Although described in the records as 'mortality at birth', this may in fact include deaths occurring at birth and during the first week of age (D Lefebvre, Valacta Inc, personal communication 2008). These included both male and female calves. Calf mortality data are provided by producers on a voluntary basis. These data are collected monthly from producers' records or verbally during a farm visit by Valacta technicians who input these data into the Valacta database.

Producers' estimates

We found that few Quebec producers kept good records of calf illness and deaths on their farm, so we asked the producers to provide estimates of juvenile mortality and morbidity. This was done either by mail (87 herds) or through telephone interviews (28 herds). The rate of mail reply was 65%, which was similar to other mail questionnaire studies (eg Pettersson *et al* 2001). The variable generated from this qualitative assessment of calf (female calves only) mortality was estimated deaths that occurred at birth and during the first week of life for Quebec herds (n = 61). We also asked Quebec producers whether or not they considered calf mortality to be a major problem or a minor problem on their farm (n = 79), and to classify the level of morbidity as either high or low (n = 80). Finally, in order to evaluate if producers perceive the financial losses through calf management and health issues, we asked Quebec producers (n = 77) to estimate the cost to raise a calf (rearing cost).

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Table 1 Management practices that can affect calf welfare, organised into area of management (calving management and care of the newborn, colostrum management, calf-dam separation, painful procedures and calf feeding), variable, code and description or unit generated from the questionnaire on calf-management practices.

Area of management	Variable	Code	Description/Unit
Calving management and care of the newborn	Type of calving area	1	Regular free- or tie-stall
		2	Individual calving pen
	Use of calving pen	1	Calving pen
		2	No calving pen
	Use of calving pen as hospital pen	1	Sometimes
		2	Never
	Use of camera for calving checks	1	Yes
		2	No
	Number of visits during the day for calving checks	Continuous	Number
	Number of visits during the night for calving checks	Continuous	Number
	Navel disinfection	1	Yes
		2	No
	Time of calf identification (ear-tagging)	Continuous	Day
Colostrum management	Time of first colostrum meal	1	< 2 h after birth
		2	> 2 h after birth
	Colostrum supply by the dam	1	Yes
		2	No
	Colostrum supply by bottle teat	1	Bottle-teat
		2	Bucket or oesophageal tube
	Quantity of colostrum during first 12 h	Continuous	L
	Quantity of colostrum during 12–24 h	Continuous	L
	Duration of colostrum feeding	Continuous	Day
	Stocks of colostrum	1	Yes
		2	No
Calf-dam separation	Time of separation	1	Before 6 h after birth
		2	After 6 h after birth
Painful procedures	Age at de-horning	Continuous	Day
	Use of anaesthetic during de-horning	1	Yes
		2	No
Calf feeding	Use of unpasteurised waste milk	1	Yes
		2	No
	Use of milk substitute (and no use of unpasteurised waste milk)	1	Yes
		2	No
	Quantity of milk during first week of milk feeding	Continuous	L
	Quantity of milk during second week of milk feeding to week before last week of milk feeding	Continuous	L
	Quantity of milk during last week of milk feeding	Continuous	L

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Table 2 Management practices that can affect calf welfare, organised into area of management (calf feeding, weaning, calf housing), variable, code and description or unit generated from the questionnaire on calf-management practices.

Area of management	Variable	Code	Description/Unit
Calf feeding	Method of distribution of milk feeding	1	Bottle teat or automatic feeder
		2	Bucket
	Age at water access	Continuous	Day
	Age at concentrate access	Continuous	Day
	Ad libitum concentrate	1	Yes
		2	No
	Age at hay access	Continuous	Week
	Ad libitum hay access	1	Yes
		2	No
Weaning	Criteria for weaning	1	Age
		2	Concentrate consumption
	Age at weaning	Continuous	Week
	Weight at weaning	Continuous	Kg
	Concentrate consumption at weaning	Continuous	Kg
	Abrupt weaning	1	Abrupt
		2	Gradual
	Gradual weaning by reducing quantity of milk or substitute	1	By reducing quantity
	Gradual weaning by diluting milk or substitute with water	2	By reducing number of meals
		1	By diluting
		2	By reducing number of meals
Calf housing (unweaned calves)	Individual housing only	1	Yes
		2	No
	Housing in the cow barn	1	In cow barn
		2	Other
	Calf tied	1	Tied
		2	Pen
	Calf in crate	1	Crate
		2	Pen
	Calf in hutch	1	Hutch
		2	Pen
	Little material in individual housing	1	Straw
		2	Wood-shaving
	Litter material in group housing	1	Straw
		2	Wood-shaving or sawdust
	Number of groups of calves on-farm	Continuous	Number
	Maximum number of calves per group	Continuous	Number
	Time that calves stay in the same group	Continuous	Week

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Table 3 Incidences (male and female calves) and producers' estimates (female calves only) of mortality from birth to one week of life in Quebec surveyed herds, incidences of mortality and morbidity for unweaned female calves in Central Europe surveyed herds.

Variable	N[†]	MIN[‡]	P25[§]	MED[#]	P75[¶]	MAX[¥]
Quebec						
Total mortality (%) at birth and during the first week of life for male and female calves	80	0	6.7	9.6	11.5	19.4
Estimated deaths (%) that occurred at birth and during first week of life for female calves	61	0	3	6	10	20
Central Europe						
Total mortality (%) for unweaned female calves	58	0	0	0	5.4	20.0
Total morbidity (%) for unweaned female calves	58	0	12.3	43.1	64.9	233.3

[†] Number of herds; [‡] Minimum; [§] 25th percentile; [#] Median; [¶] 75th percentile; [¥] Maximum.

Statistical analysis

The questionnaires returned were examined individually for aberrant results, and an answer was excluded when a question had obviously been misunderstood. Descriptive statistics calculated were the percent of farms giving a particular response (in the case of qualitative questions) and the minimum (Min), 25th percentile (P25), median (MED), 75th percentile (P75) and the maximum (Max) values for continuous variables.

The SAS statistical package, version 9.2 (SAS Institute Inc, Cary, NY, USA) was used to analyse the data.

Mortality and morbidity incidences and producers' estimates of health

Kruskal-Wallis test (χ^2 approximation, PROC NPAR1WAY) was used to test for differences between Austria vs Germany in mortality and morbidity for unweaned calves in order to combine them in the analysis (referred to as Central Europe). Spearman rank correlation coefficient (PROC CORR) was calculated between morbidity and mortality in Central Europe. Spearman rank correlation coefficient (PROC CORR) was calculated between producers' estimates of mortality and database data of mortality for Quebec in order to evaluate producers' accuracy to evaluate mortality. Wilcoxon signed rank test (PROC UNIVARIATE) was used to evaluate if the difference between recorded and estimated mortality in Quebec was significantly different than zero. Kruskal-Wallis test (χ^2 approximation, PROC NPAR1WAY) was used to analyse the differences in estimated mortality rates between producers who considered themselves as having either a major or a minor problem with calf health (mortality incidence) or as having high or low morbidity incidence in Quebec herds.

Relationships between health status and management practices

To test whether the records of calf mortality or morbidity did reflect the use of risky management practices, we used single logistic regressions (Wald χ^2, PROC LOGISTIC) with management practices as explanatory variables. The two dependent variables were our measures of health status for the herd: morbidity for Central Europe, and mortality at birth and during the first week of age (both male and female) for Quebec. Both dependent variables were previously ranked due to non-normal distributions; for this reason, logistic regression analysis has been used to explain these categorical dependent variables (Allison 1999). We decided not to use recorded incidence of mortality in Central Europe as dependent variable because too many zeros were included (Table 3). Analyses were conducted separately for Quebec and Central Europe herds.

Comparison of management practices between Quebec and Central Europe herds

Chi-squared statistics on qualitative variables (PROC FREQ) and Wilcoxon statistics on quantitative variables (PROC NPAR1WAY) were used to compare the use of management practices between Quebec and Central Europe herds. Due to the large number of variables included in the analysis, we used a Bonferroni correction for the critical probability values.

Results

Mortality and morbidity incidences and producers' estimates of health

There were no significant differences between farms in Austria and Germany in annual calf mortality ($\chi^2 = 0.605$, $P > 0.1$) and morbidity ($\chi^2 = 0.197$, $P > 0.1$) and so these were combined in all analyses. The recorded incidence and the producers' estimates of mortality and morbidity are shown in Table 3. According to records, there was a very large variation between farms in mortality and morbidity. The overall mortality (including still births) in Central Europe was very low compared to Quebec despite the fact that in Quebec it included only deaths occurring at birth and during the first week of age. In Central Europe, recorded calf morbidity was not correlated with recorded mortality ($r = 0.142$, $P > 0.1$).

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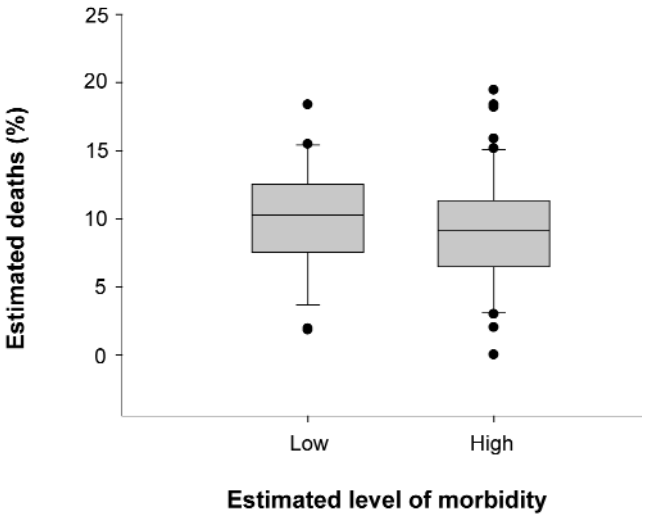
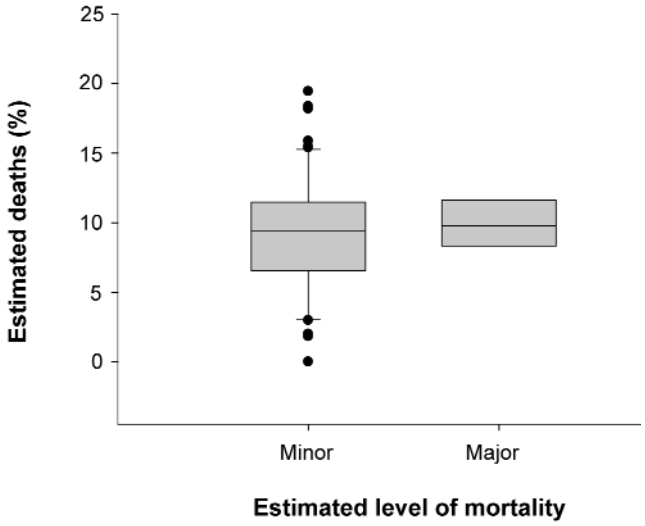
Figure 1



Estimated deaths (%) that occurred at birth and during first week of life for female calves by Quebec producers estimating having high (Mean [± SD], 8.9 [± 4.4]; n = 53) vs low (10.0 [± 4.1]; n = 27) levels of morbidity incidence (χ^2 = 1.972, $P > 0.1$).

Figure 2



Estimated deaths (%) that occurred at birth and during first week of life for female calves by Quebec producers estimating having major (Mean [± SD], 9.9 [± 2.0]; n = 5) vs minor (9.2 [± 4.4]; n = 74) levels of mortality incidence (χ^2 = 0.285, $P > 0.1$).

In Quebec, there was no correlation between mortality at birth and during the first week that was recorded in the database and the producers' estimates (r = 0.010, $P > 0.1$). Overall, Quebec producers underestimated mortality rates: when estimated mortality was subtracted from reported mortality during the first week, the difference was positive (P25 = 1, MED = 2, P75 = 5; $S_{\text{Wilcoxon signed rank}}$ = 375.5, P = 0.006).

In Quebec, the producers who considered themselves as having a high calf morbidity did not estimate higher rates of mortality than the producers who considered themselves as having low morbidity (χ^2 = 1.972, $P > 0.1$) (Figure 1). Producers who considered themselves as having major problems of mortality did not estimate higher rates of mortality than the producers who considered themselves as not having problems (χ^2 = 0.258, $P > 0.1$) (Figure 2).

Half of Quebec producers estimated the rearing costs to be 2,000 CAD or less (P25 = 1,800; MED = 2,000; P75 = 2,350 CAD).

Relationships between health status and management practices.

In Quebec herds (Table 4), the single regressions of the relationship between each management practice and mortality did not show any strong associations between mortality and management practices. A significant association with mortality was found only with lower quantities of colostrum during 12–24 h after birth (β = –0.251, SE(β) = 0.127, χ^2 = 3.92, P = 0.048), which was no longer significant if a Bonferroni correction was used (significance threshold after Bonferroni correction: α = 0.001). In Central European herds (Table 5), higher incidences of morbidity were associated with no stock of colostrum (β = 1.25, SE(β) = 0.49, χ^2 = 6.41, P = 0.011), higher quantities of milk during the last week of milk feeding (β = 0.22, SE(β) = 0.11, χ^2 = 4.24, P = 0.048), smaller quantities of concentrate consumption at weaning (β = –0.779, SE(β) = 0.38, χ^2 = 4.19, P = 0.041) and a longer time that calves stayed in the same group (ie higher group stability) (β = 0.048, SE(β) = 0.024, χ^2 = 3.88, P = 0.049). However, none of these were significant if a Bonferroni correction was used (significance threshold after Bonferroni correction: α = 0.001).

Comparison of management practices between Quebec and Central Europe herds

Quebec and Central European producers differed significantly in their use of many management practices (Tables 6 and 7). In terms of calving management and care of the newborn, Central European dairy herds differed from Quebec dairy herds in more use of the calving pen as a hospital pen. In terms of colostrum management, colostrum is provided more often by a teat bottle in Central European herds, more herds have stocks of colostrum and colostrum is supplied during a longer period than in Quebec herds. In terms of calf feeding, milk is supplied more often by a teat system and quantities of milk are greater than in Quebec herds. Water, concentrate and hay access are delayed in Central Europe and unweaned calves are more likely to have *ad libitum* access to hay than in Quebec herds. In terms of weaning, calves are weaned later and heavier than in Quebec herds while eating less concentrate. In terms of calf housing, less Central European than Quebec herds housed calves in the cow barn.

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Table 4 Single logistic regressions results for significant associations between management practices and incidences of mortality at birth and during the first week of life (male and female calves) in Quebec.

Variable	Code	Description	N	β	SE (β)	χ^2	*P*-value	OR (95% CL)
Time of calf identification (ear tagging)	Continuous		80	0.045	0.027	2.787	0.095	1.046 (0.992, 1.103)
Quantity of colostrum during 12–24 h	Continuous		78	–0.251	0.127	3.922	0.048	0.778 (0.606, 0.997)
Ad libitum hay access	1	Yes	54	0.902	0.463	3.793	0.051	2.466 (0.994, 6.114)
	2	No	20					
Age at weaning	Continuous		80	0.108	0.062	3.060	0.080	1.114 (0.987, 1.257)

Table 5 Single logistic regressions for significant associations between management practices and incidences of morbidity for unweaned calves (female calves) in Central Europe.

Variable	Code	Description	N	β	SE (β)	χ^2	*P*-value	OR (95% CL)
Quantity of colostrum during 12–24 h	Continuous		56	0.310	0.159	3.813	0.051	1.364 (0.999, 1.862)
Stocks of colostrum	1	Presence	40	1.250	0.494	6.405	0.011	3.491 (1.326, 9.193)
	2	Absence	17					
Quantity of milk during last week of milk feeding	Continuous		58	0.220	0.107	4.242	0.039	1.246 (1.011, 1.536)
Age at water access	Continuous		54	–0.029	0.013	5.018	0.025	0.971 (0.947, 0.996)
Age at weaning	Continuous		58	–0.127	0.071	3.193	0.074	0.881 (0.766, 1.012)
Weight at weaning	Continuous		39	–0.017	0.009	3.548	0.060	0.984 (0.967, 1.001)
Concentrate consumption at weaning	Continuous		52	–0.779	0.380	4.193	0.041	0.459 (0.218, 0.967)
Time that calves stay in the same group	Continuous		40	0.048	0.024	3.881	0.049	1.049 (1.000, 1.100)

Table 6 Chi-square statistics on qualitative variables: significant differences in management practices between Central Europe (CE) vs Quebec (QC) herds.

Variable	Description	CE Pct*	QC Pct*	χ^2	*P*-value
Type of calving area	Regular free- or tie-stall	21.6	50.6	8.743	0.003
	Individual calving pen	78.4	49.4		
Use as hospital pen	Sometimes	87.8	58.2	10.5	0.001
	Never	12.2	41.8		
Colostrum supply by bottle teat	Bottle teat	92.5	56.7	14.967	0.0001
	Bucket or oesophageal tube	7.5	43.3		
Stocks of colostrum	Presence	70.2	28.7	22.996	< 0.0001
	Absence	29.8	71.3		
Time of the separation	Before 6 h after birth	70.7	46.8	7.762	0.005
	After 6 h after birth	29.3	53.2		
Use of unpasteurised waste milk	Yes	72.3	47.4	7.385	0.007
	No	27.7	52.6		
Method of distribution of milk feeding	Bottle teat or automatic feeder	66.7	15.4	37.140	< 0.0001
	Bucket	33.3	84.6		
Ad libitum hay access	Yes	96.5	73.0	12.745	0.0004
	No	3.51	27.0		
Individual housing only	Yes	74.1	88.7	4.997	0.025
	No	25.9	11.3		
Housing in the cow barn	In cow barn	45.3	82.3	19.766	< 0.0001
	Other	57.3	17.7		

* Percentage of herds.

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Table 7 Wilcoxon statistics on quantitative variables: significant differences in management practices between Central Europe (CE) vs Quebec (QC) herds.

Variable (unit)	CE*	QC*	*Z*	*P*-value
Number of visits during the day for calving checks (number)	4.3 (± 0.6)	3.6 (± 0.2)	1.552	0.060
Duration of colostrum feeding (days)	6.3 (± 0.2)	3.0 (± 0.1)	9.145	< 0.0001
Quantity of milk during first week of milk feeding (L)	5.7 (± 0.2)	4.6 (± 0.2)	5.000	< 0.0001
Quantity of milk during second week of milk feeding to week before last week of milk feeding (L)	7.0 (± 0.2)	5.6 (± 0.2)	4.849	< 0.0001
Quantity of milk during last week of milk feeding (L)	3.8 (± 0.3)	3.1 (± 0.2)	1.386	0.083
Age at water access (days)	17.6 (± 2.6)	5.2 (± 0.7)	5.742	< 0.0001
Age at concentrate access (days)	14.8 (± 1.4)	11.5 (± 2.0)	3.701	0.0001
Age at hay access (weeks)	9.9 (± 0.8)	3.8 (± 0.4)	5.999	< 0.0001
Age at weaning (weeks)	10.8 (± 0.4)	7.2 (± 0.4)	7.500	< 0.0001
Weight at weaning (kg)	116.3 (± 5.3)	88.1 (± 3.4)	5.492	< 0.0001
Concentration consumption at weaning (kg)	1.2 (± 0.1)	2.0 (± 0.1)	–5.031	< 0.0001

* Mean (± SEM).

Discussion

We found a number of problems in attempting to use recorded incidences of calf mortality or morbidity to assess the level of calf health on individual farms. The use of risky management practices seemed to relate to differences in calf health between geographical regions.

The first problem involved the quality of records kept and differences between regions in the type of data collected. In Central Europe, producers kept their own records of mortality and morbidity, of which we could not judge the accuracy. In Quebec, reported levels of mortality were recorded officially only for mortality at birth but, in reality, this may include deaths that occurred during the first week of life. Due to the lack of health records, no data on calf diseases were available for Quebec herds. Monitoring of calf diseases on a national level is seldom reported from any country (LeBlanc *et al* 2006) and the accuracy of these recordings is questionable. For example, Gulliksen *et al* (2009b) tested the reliability of calf disease records in the Norwegian national recording system and showed an underestimation of 40% based on their most reliable producer's health records. This emphasises the considerable challenge of keeping standardised, valid and systematically recorded health data at the herd level, despite the number of software tools available and services offered by Dairy Herd Improvement or veterinary associations.

We hoped that we could use the incidence of mortality in Quebec herds to estimate the overall health status of the calves or to use producers' estimates of both mortality and morbidity. However, in Central European herds, we found that mortality and morbidity incidences were not correlated. This poor relationship between mortality and morbidity is reflected in the producers' self-assessments. In fact, the producers who estimated higher incidences of morbidity did not estimate higher mortality rates (Figure 1). This may indicate that producers having a high incidence of morbidity avoid calf deaths by successfully treating the animals. On the other hand, this low correlation may be due to the generally low incidence of mortality seen in the European herds.

Producers were not accurate in estimating mortality incidence and the seriousness of calf mortality was underestimated in Quebec. Overall, very few of the surveyed producers (6.3%) stated that calf mortality was a major problem on their farms. Interestingly, Figure 2 illustrates that the producers who actually stated that calf mortality was not a major problem on their farms still estimated their mortality rate at 9.2%. This perception of calf mortality as not being a major problem, likely results in producers perceiving calf mortality to be less frequent than it is. The lack of mortality records kept on Quebec farms may reflect and contribute to producers thinking that calf mortality is not a serious problem. Moreover, half of Quebec producers estimated the cost of raising a calf to be 2,000 CAD or less, while average rearing costs in Quebec are evaluated to 2,500 CAD (Pellerin & Guilbert 2008). This underestimation of calf rearing costs may reflect that producers do not perceive financial losses through calf rearing, including management, health issues and mortality. This may contribute to producers thinking that calf rearing is not really costly and calf mortality is not a serious problem, at least in financial terms, which may lead to producers not taking action to improve calf health and management. Similarly, Vaarst and Sørensen (2009) stated that the producer's perception of calf mortality as a serious problem contributed to his reactivity to take actions to solve this problem (eg adoption of health records and better management practices).

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The Central European herds are more likely to keep health records and their unweaned calves seem to have a good health status. The new Canadian Dairy Code of Practice (Dairy Farmers of Canada 2009) recommends keeping complete, accurate and reliable records of health events. An effective on-farm intervention can improve record-keeping: recently in Quebec (Vasseur *et al* 2010b), producers were asked to record calf mortality and diseases events over a 6-month period in the context of an on-farm intervention. Six months after the intervention, 75% of the producers (versus 36% before the intervention) were still routinely recording calf mortality and morbidity. Hopefully, knowledge of the European success, the new Code of Practice and the use of on-farm intervention tools for calf rearing will help Canadian producers keep better mortality and morbidity records.

From the data that were available, we found lower mortality rates in Central Europe than in Quebec herds. Based on recent large-scale epidemiological studies or national recording systems, calf mortality rates reported in European countries tend to be less than 5% (Svensson *et al* 2006; Gulliksen *et al* 2009a) while they are closer to 8% in the US (USDA 2008). However, the median value of 0%, mortality for unweaned calves reported in the surveyed Central European herds was lower than results reported in other studies (Svensson *et al* 2006; Gulliksen *et al* 2009a). On the other hand, with a median mortality from birth to one week of age of 9.6%, surveyed Quebec herds had higher rates than reported in the US for the total period from birth to weaning (around 8 weeks, USDA 2008). However, the calf mortality data in this study must be considered in the light of limitations associated with the data source, ie missing data in producers' records and bias introduced by lack of a standard procedure of death records (male or female, age at death, etc).

Within countries, we found no strong associations between management practices and health status. In Quebec herds, this could be explained, in part, by the fact that the measures of mortality were primarily mortality at birth or during the first week of age, which would be explained by factors other than calf management, eg genetic factors like type of bull used for AI, calf birth weight or cow management, eg difficulties at calving. We have no explanation for the lack of association between management practices and calf health status in Central Europe. Together, these results show that measures of calf mortality and morbidity recorded by the surveyed producers are not good indicators as to whether or not risky management practices are being used on a farm.

Quebec dairy producers reported using more practices that are associated with poor health in calves than did Central European ones, which may explain the better calf health status in Central European herds. These include no frozen stocks of colostrum, which is not recommended and shows a lack of awareness of the importance of timely colostrum feeding (Weaver *et al* 2000), and low quantities of milk (10% of bodyweight) that are insufficient to cover calf maintenance needs (Drackley 2008). However, Central European producers also used some poor practices, such as use of calving pen as a hospital pen, which is a potential source of disease for newborn calves, supply of unpasteurised waste milk which can increase risks for transmission of infectious pathogens (Selim & Cullor 1997). This reflects that, from the surveyed herds, the available recorded mortality and morbidity do not necessarily fully show the extent that producers use management practices that pose a risk to calf health.

Conclusion

From our findings, we conclude that, at present, to accurately assess the extent that the welfare of calves on a farm or in a region is affected by poor health, it is important to use both measures of the incidence of diseases and mortality (outcome-based measures) and information on the use of management practices that place calf health at risk. Outcome-based measures, such as measures of poor health, are often favoured because they relate more directly to the actual state of the animals (Knierim & Winckler 2009). However, taking outcome-based measures of health status is problematic. First, measures of the prevalence of disease are time consuming and only give a measure of health during a narrow time window, which may not be representative of a longer time-period. Measures of incidence require the use of records and the present study shows that producers' record-keeping habits and databases (in some parts of the world) are far from ideal, and producers themselves have difficulty estimating calf mortality or morbidity on their farms. Furthermore, from the surveyed herds, morbidity and mortality records available do not fully show the extent that producers do use management practices that are known from research to place the calf health at risk.

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