PAPER

Management risk factors for calf mortality in intensive Italian dairy farms

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Abstract

High calf mortality is an important factor of economic loss in dairy production. At present, limited data are available on calf rearing practices and calf mortality in Italian dairy farming. The aim of the study was to identify the most important management risk factors for preweaning calf mortality in Italian dairy farms. A group of 28 intensive dairy farms from Lombardy (Italy) were visited to collect information about calf management and calf mortality. Female calf mortality showed high variability among herds and in many cases the percentage of calves dead within the preweaning period was very high. The average perinatal mortality (during calving and within 24 h after birth) was 8.82% of total females born with a maximum value of 30.8%, whereas average early mortality (from 24 h to weaning) was 8.9±7.9%, with a maximum value of 28%. The herd size did not significantly affect calf mortality although the number of calves cared per operator in the big farms was higher than in the small ones. Multivariate logistic analysis showed that feeding first colostrum meal beyond three hours after birth, group housing before 30 d of age and feeding daily less than 5 L of milk or milk replacer per calf multiply the risk to have early mortality higher than 10%. The study showed that early calf mortality could be strongly reduced by paying more attention to a very limited number of operations.

Introduction

High calf mortality is an important factor of economic loss in dairy production (Mee, 2008). Calf death represents a cost to the dairyman due to the loss of the present value of the calf and the loss of genetic potential for herd improvement. High calf mortality rates may also delay progress in replacing cull cows or increasing the herd size (Wathes *et al*., 2008). It might consequently result in a shortage of replacement heifers and a need to buy animals that further increases the replacement costs of the herd (Torsein *et al*., 2011).

The highest mortality risk occurs during the first 3 weeks of life (Wells *et al*., 1996). Calf mortality during calving and within the first 24-48 h *post-partum* is defined as perinatal mortality and it is mainly related to dystocia (Gundelach *et al.*, 2009). Perinatal mortality is often poorly documented and may be underestimated due to lack of registrations at the farm level. Main causes of calf death during the first month of life are gastrointestinal disorders (Torsein *et al*., 2011) and pneumonia; they are influenced by housing conditions, colostrum intake and feeding management (Wathes *et al*., 2008). Newborn and growing dairy calves require appropriate amounts of quality feed and a satisfactory farm environment that provides for thermal, physical and behavioral comfort. Inadequate environmental and feeding conditions may be a source of stress for calves, which may subsequently compromise immune responses, growth rates, disease resistance, and well-being (Stull and Reynolds, 2008).

Calves need colostrum for disease prevention and nutrition. Colostrum is the first secretion of the mammary gland after calving and it is an important source of nutritional, growth, and antimicrobial factors for the newborn calf. Good quality colostrum, with high level of Immune-globulin (Ig), fed as soon as possible after birth, is necessary to minimize disease susceptibility and mortality (Gulliksen *et al*., 2009). European Directive 2008/119/EC on calf protection (European Commission, 2008) requires that each calf receives bovine colostrum as soon as possible after it is born and in any case within the first six hours of life. Godden (2008) recommended to separate the calf from the dam within 1 to 2 h after birth in order to feed a known volume of clean colostrum using either a nipple bottle or an esophageal feeder; according to the same author at first feeding calves should be fed 10% to 12% of their body weight with colostrum (3.78 L for a 43 kg calf). Early calf-dam separation, within 12 h from birth, is also suggested in order to decrease the risk of exposure to environmental pathogens and to facilitate first care (Windsor and Whittington, 2010). In particular, for prevention of MAP disease, it would be better to separate calf from dam within 4 h because the contact of calves with adult cow faeces is the most important risk factor (Dorè *et al.,* 2012).

The amount of milk or milk replacer admin-

istered daily to calves is usually equivalent to 10-12% of their live weight, but recently some studies have shown advantages in feeding higher doses of milk. Khan *et al*. (2007) found that, with an amount of milk of 20% of body weight, calves exhibited increased growth, improved mammary development, accelerated age at first calving, and increased milk production during first lactation. Minimum standards on calves feeding are also included in the European regulations (European Commission, 2008): feed must contain sufficient iron to avoid calf anemia, a minimum daily ration of fibrous feed must be provided for each calf over two weeks old and sufficient quantity of fresh water has to be administered.

European regulations (European Commission, 2008) also establish requirements for housing and management of calves to preserve their health and welfare: individual pen are allowed until eight weeks of age, minimum space requirements are fixed, all housed calves must be inspected at least twice daily, calves must not be tethered all the time, they have to be free of lying, standing and take care to themselves in a clean place with adequate and comfortable bedding. Dairy calf and heifer management has been previously examined in a number of studies in the international scientific literature but at present very few data are available on rearing systems and mortality of

dairy calves in Italian dairy farms (Colnago *et al.*, 2007).

The objectives of this study were: i) to examine the relationship between mortality among preweaned female calves and management practices on intensive dairy farms in Northern Italy and ii) to identify the main management risk factors for high mortality rates.

Materials and methods

A group of 28 intensive dairy farms were selected out of the database of a local farmer association (Associazione Provinciale Allevatori Bergamo) on the basis of the following criteria: location in plain area, herd size between 20 and 400 lactating cows, Italian Holstein cattle and willingness to collaborate. A questionnaire was personally administered to the farmers in order to collect information about herd composition, production level, routine calf management operations, calf housing and number of female calves dead before weaning. All data refer to the year 2009.

Moreover, group pens for calves were measured; calf mortality was described in terms of perinatal mortality (during calving and within 24 h from birth) and early mortality (between 24 h of life and weaning).

Statistical analysis

Data were analyzed by Proc GLM (SAS 9.1, 2001) to test the influence of herd size on calf rearing and mortality.

The model used was:

$$Y_{ijklm} = \mu + T_i + M_j + S_k + H_l + e_{ijklm}$$

where

Y_{ijklm} = dependent variables;

μ = general mean;

T_i = effect of time between birth and first colostrum meal (i= <3 hours; ≥3 hours);

M_j= effect of average daily amount of milk or milk replacer before weaning (j= <5 L/d; ≥5 L/d); S_k= effect of time in single pens (k= <30 d of life; ≥30 d of life);

H_l= effect of herd dimension (l= ≤150 lactating cows, >150 lactating cows);

e_{ijklm} = residual error.

Relationships among early mortality (between 24 h of life and weaning), amount of colostrum given to calves, time between birth and first colostrum meal, time between birth and dam separation, milk or milk replacer daily amount, time in single pen, and number of calves cared per operator were evaluated

through a multiple correspondence analysis (Proc CORRESP; SAS, 2001) to find a two-dimensional graphical representation of the rows and columns of a contingency table.

A multivariate logistic analysis was performed (Proc LOGISTIC; SAS, 2001) in order to identify the variables associated with early mortality. The logistic regression analyses examined all possible interactions among variables. The end results of the analyses were final models including all variables (risk factors) significantly associated with early mortality. The models were described in terms of odds ratios, with 95% confidence intervals.

Results and discussion

Herd characteristics and calf management practices

Table 1 shows the major characteristics of the herds involved in the study, main calf management practices and female calf mortality during preweaning period. The average number of lactating cows was 144±88.3, similar to the average size of Italian Holstein herds in Lombardy (145 cows/farm; AIA, 2010). Milk production was 11,399±1729 kg/cow per year, higher than the average milk yield for Italian Holstein cows in Lombardy

(9273±2000; AIA, 2010).

Parameters related to calf management (*e.g.* time from birth to dam separation, time of first colostrum meal, colostrum amount) varied considerably among farms, highlighting wide areas for improvement. It is useful to underline that such parameters were not measured on field but were obtained from the statements of the farmers: they represent the most common procedures applied in each farm, but do not provide any information about the variability within each farm.

Time of calf-dam separation varied from 5 min to 12 h from birth; the majority of the farms (75%) separated newborn calves from their mothers within 3 h from birth. An early separation is crucial to reduce pathogen exposure and to control colostrum intake (Windsor and Whittington, 2010). The frequency distribution of time between birth and first colostrum meal showed a great variability among herds (Figure 1): on average, the first meal was administered after 251±130 min (about 4 h) from birth, but in some cases calves received colostrum 8 h after birth. According to Godden (2008) it is important to assure an adequate intake of high-quality colostrum within the first 4 h *post-partum* when the efficiency of Ig transfer across the gut epithelium is optimal; after 6 h there is a progressive decline in the absorption of Ig. The number of colostrum meals during the first 24

Table 1. Herd characteristics, calf management practices and female calf mortality during preweaning period in the 28 evaluated farms.

	Mean	SD	Minimum	Maximum
Herd size, n	327	209	40	900
Lactating cows, n	144	88.3	20	400
Milk yield, kg/d	31.2	4.74	20	40.4
Lactation, n	2.56	0.51	1.80	4.00
Calves (from birth to weaning), n	26.4	20.0	0.00	80.0
Calves (from birth to weaning), % of total herd	7.61	2.61	0.00	11.9
Calves (from weaning to 6 mo), n	29.0	19.3	2.00	86.0
Calves (from weaning to 6 mo), % of total herd	9.18	3.87	3.80	21.4
Time birth-dam separation, min	104	155	5.00	720
Time birth-colostrum meal, min	251	130	10.0	480
Colostrum meals, n/d	2.04	0.51	1.00	3.00
Colostrum amount, L/d	3.95	1.84	1.50	8.00
Milk meals, n/d	2.00	0.47	1.00	4.00
Milk amount, L/d	5.23	1.37	3.00	8.00
Age at solid feed supplementation, d	7.29	5.42	1.00	25.0
Age at weaning, d	78.2	17.2	40.0	120
Time in single pen, d	39.4	21.5	0.00	70.0
Calves/operator, n	50.1	36.5	2.00	153
Time calf management, h/d	2.11	1.20	0.30	6.00
Perinatal mortality°, %	8.82	7.88	0.00	30.8
Early mortality#, %	8.88	7.86	0.00	28.0

°Mortality between birth and 24 h; #mortality between 24 h and weaning.

h of life was similar to the results reported by Vasseur *et al.* (2010) but the amount of colostrum given in the first day was higher. Milk or milk replacer was generally fed twice a day in the average daily amount of 5.23±1.37 L, lower than the recommendations of Khan *et al.* (2007). Colnago *et al.* (2007) in a previous survey on Italian dairy herds reported higher average milk daily intake in the first 60 days of life (6.1 L/d). Calves were offered solid feeds, generally grain or concentrates, starting from approximately one week after birth. European Directive 2008/119/EC on calf protection (European Commission, 2008) requires that a minimum daily ration of fibrous feed must be provided to each calf over two weeks old.

In the present study, calves were weaned at 78.2±17.2 d on average, earlier than 99 d reported by Colnago *et al.* (2007). Calves were housed in single pens for 39.4±2.5 days on average, thereafter they were grouped. In a Swedish study individual pen was used only for the first two weeks of life (Torsein *et al.*, 2011). A study from Gulliksen *et al.* (2009) indicated that housing calves in group pens during the first month of life is disadvantageous compared with individual housing: calves in group pens are likely to experience greater exposure to higher levels of infectious agents earlier in their life than calves housed individually, which may result in increased infections and death rates. However, group housing enables social interactions among calves and satisfies their need for motion and play. It is therefore considered preferable from a welfare point of view (De Paula Vieira *et al.*, 2010, Gulliksen *et al.*, 2009).

The age at which calves were grouped was different from the average age at weaning, showing that calves were generally grouped before weaning. This can be considered a good practice because it avoids the sum of stressing stimuli induced by weaning and grouping. Space in the pens should be enough to allow calf movements. Single and group pens were measured in 15 farms: space per calf in group pens was on average 3.54 m², much higher than minimum standards of European regulation and no farm breached European limits. Length and width of individual pens were consistent with European requirements in 7 farms but too small in the remaining 8 farms. According to Vasseur *et al.* (2010), keeping calves for long time in individual and inappropriate housing conditions (*e.g.* small crates, tie-stall) is a risk factor for poor calf welfare.

Calf mortality

Female calf mortality showed high variability among herds. The average perinatal mortality (during calving and within 24 h from birth) was 8.82% of females born similar to the average percentage of 7.9% observed by Wathes *et al.* (2008). Gulliksen *et al.* (2009) reported a lower percentage of perinatal mortality (3.4%) while Ettema and Santos (2004) a higher value (16.5%). The maximum value of perinatal mortality was very high (30.8%) and approximately one third of the herds (28.6%) showed percentages higher than 10%. Average early mortality (from 24 h to weaning) was 8.9±7.9%, higher than 3.4% reported by Wathes *et al.* (2008). According to Colnago *et al.* (2007) the average mortality of female calves in 2003 during the first month of life (stillbirth included) was 15.3%. In 35.7% of herds early calf mortality was higher than 10% with a maximum value of 28%.

Effect of herd size

Herd size did not affect calf mortality: the group of 14 farms with more than 150 lactating cows had perinatal mortality (from birth to 24 h) of female calves of 9.39% and early mortality

Table 2. Logistic analysis of risk management factors associated to >10% of calf early mortality.

	Odds ratio°	95% Confidence interval	P
Effect			
Time birth-colostrum meal ≥3 h *vs* <3 h	84.0	2.04->999	0.019
Time in single pen <30 d *vs* ≥30 d	21.3	1.16-390	0.039
Milk amount <5 L/d *vs* ≥5 L/d	10.9	0.86-137	0.066

°Odds of having >10% early mortality.
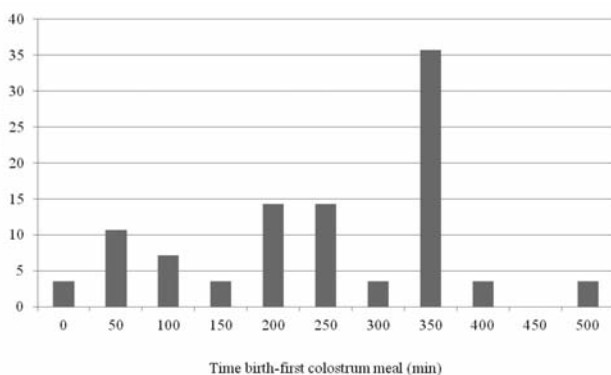
Figure 1. Frequency distribution of time between birth and first colostrum meal (min).
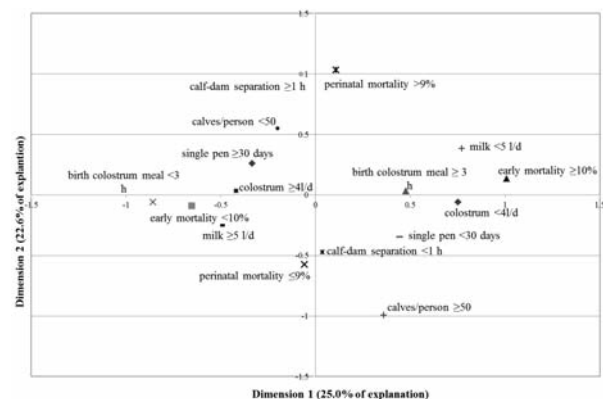
Figure 2. Multiple correspondence analysis of farm characteristics.

(from 24 h to weaning) of 9.16%, similar to the average mortality percentages of the 14 smaller farms (7.69% and 8.38%, respectively). In larger farms the number of calves cared per operator was double compared to smaller farms (65.3 *vs* 30.1; P<0.01); the daily time for calf management was consequently higher (2.51 *vs* 1.59 h/d; P<0.05). In large farms, the operator taking care of calves is likely more qualified and dedicates longer time to this activity compared with small farms. Literature reported conflicting results: Gullisken *et al*. (2009) showed an increase in calf mortality rates in all age groups as herd size increases; this is probably due to a reduction of time spent in the barn for the daily inspection of each individual animal. On the contrary, Jago and Berry (2011) reported a lower incidence of perinatal mortality in medium and big farms in comparison with small farms and this could be due to a better management of animals around calving or, alternatively, to under-recording of this trait by the farmers.

Multiple correspondence analysis

Figure 2 shows the relation among parameters considered throughout a multiple correspondence analysis. The first dimension explains 25.0% of the total variation while the second dimension explains 22.6%. The analysis identified two main groups of related parameters: in the first group low early mortality rate (<10%) was associated with time of colostrum feeding within 3 h from birth, more than 4 L of colostrum in the first day, housing in single pen for more than one month, less than 50 calves cared per person, milk fed daily higher than 5 L. On the contrary high early mortality rate (≥10%) was associated with scarce attention to colostrum feeding in terms of time from birth and amount, administration of low amount of milk and housing calves in single pens for too short time. The positive relation between low early mortality rate and housing calves in single pen in the first month of life was also reported by Gullisken *et al*. (2009).

Multivariate logistic analysis

Multivariate logistic analysis was performed to identify the main management risk factors for calf early mortality, from 24 h of life to weaning. Table 2 shows that the most important factor for early mortality was the interval between birth and first colostrum meal: if the first colostrum feeding was given after 3 h from birth the risk to have high early calf mortality (>10%) was 84 times higher. A delay in colostrum feeding reduces the efficiency of Ig

transfer across the gut epithelium (Godden, 2008) exposing calves to bacterial attack. The second risk factor was housing calves in single pen for less than 30 days from birth. This is in agreement with the results of Gulliksen *et al*. (2009). However, some authors as Duve and Jensen (2011) and Chua *et al.* (2002) reported that group housing is preferable from a welfare point of view. The last management risk factor for early mortality was the insufficient amount of milk or milk replacer fed daily to calves. It is important to assure adequate amounts of milk during preweaning period: high milk consumption supports high body weight gain, reduces incidence of diseases, and provides good opportunity to express natural behaviours, which in combination suggests improved welfare (Khan *et al*., 2011).

Conclusions

Calf mortality showed high variability among herds and in many cases the percentage of calves dead within the preweaning period was very high. The average percentage was similar to other studies reported in the literature, but suggests a low efficiency of calf rearing. Herd size did not significantly affect calf mortality although the number of calves cared per operator in big farms was higher than in small ones; this suggests better specialization of the workers in big farms. Important associations between early mortality and calf management practices were underlined by multiple correspondence analysis. Multivariate logistic analysis showed that feeding first colostrum meal beyond 3 hours after birth, group housing before 30 d of age and feeding daily less than 5 L of milk or milk replacer per calf multiply the risk to have early mortality higher than 10%.

The study showed that early calf mortality could be strongly reduced by paying more attention to a very limited number of operations.

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