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Short communication: Survival, growth to weaning, and subsequent fertility of live-born dairy heifers after a difficult birth

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ABSTRACT

The experience of a difficult birth (dystocia) is traumatic and has adverse effects on the newborn in various species. Despite affecting up to 1 in 3 births in dairy cattle, studies on calves have been mostly limited to the first day of life. The objective of this study was to investigate the effects of dystocia on the survival to calving, growth to weaning, and subsequent fertility as nulliparous animals. Historical data from live-born Holstein heifer calves born from cows with various birth difficulty scores (no assistance; moderate; high difficulty) were obtained from 2 herds (Edinburgh herd: n = 1,237; Crichton Royal Farm herd: n = 721). Each herd was analyzed separately for birth weights, weaning weights, growth rate to weaning, number of services to conception, and age at first calving using REML and generalized linear mixed model analyses. Survival analysis (Cox proportional hazards model) was used in the Edinburgh herd to analyze the subsequent survival of live-born heifers, whereas descriptive data are presented for the Crichton Royal Farm herd. A higher mortality risk to weaning and to first service was observed in the live-born heifers that experienced moderate difficulty at birth compared with heifers born naturally. Surviving dystocial heifers had similar growth-to-weaning and fertility performance as heifers born naturally in both herds. It could be that the performance of dystocial heifers that survived to weaning was not affected or that it was compensated for by farm management. This study highlights long-term effects of the early experience of a difficult birth and thereby stresses the importance of preventing dystocia not just from the point of view of the adult cow, but also from the perspective of the calf. This would also improve farm efficiency and calf welfare.

Key words: dairy calf, calving ease, dystocia, heifer

Short Communication

The birth of a heifer calf represents a long-term investment in the future dairy herd. Birth is risky, however, and can require human assistance in more than one-half of calvings (Mee, 2008). Calves that survive the trauma of a difficult birth (dystocia) have higher mortality and morbidity in the neonatal period (Wittum et al., 1994a; Lombard et al., 2007). Typically, effects of dystocia have been reported in the first few days of life, with a major focus on stillbirth. Few studies have investigated survival beyond the neonatal period in dairy cattle, especially those that consider the survival of live-born calves as opposed to all calves born (stillborn or not). Survival of live-born heifer calves therefore merits further investigation. Some evidence also exists that dystocia could have long-term effects on the performance of dairy heifer calves, in addition to higher mortality and morbidity. Dystocial beef calves have reduced growth to weaning (Bellows et al., 1988; Goonewardene et al., 2003). In dairy heifers, growth rate is a good predictor of survival and also a determinant of subsequent fertility and milk production (Wathes et al., 2008; Brickell et al., 2009). Recent studies have observed reduced milk production in primiparous animals associated with the experience of dystocia (Eaglen et al., 2011; Heinrichs and Heinrichs, 2011). Lifetime survival was also poorer after the experience of at least a hard pull at birth (Henderson et al., 2011), although this was not the case for the lower degrees of birth difficulty. The objective of this study was to investigate whether the experience of a difficult delivery at birth would alter the survival of dairy heifer calves, their growth to weaning, and their subsequent fertility as nulliparous animals.

Historical data were obtained from a commercially managed experimental Holstein dairy herd (Scotland, United Kingdom). Birth difficulty was scored as follows: normal (no assistance), moderate difficulty (farmer-assisted births, calf normally presented), and high difficulty (malpresented calves and veterinary assistance). Heifer calves born between January 1, 1990, and January 31, 2000, were reared at the Langhill Farm

(**EDI** herd, Edinburgh, UK), and calves born between January 1, 2002, and April 26, 2009, were reared at the Crichton Royal Farm (**CR** herd, Dumfries, UK). Data included birth weight, weaning weight (**WW**), growth rate to weaning (**GRW**; g/d), number of services to conception (**NSERV**), and the subsequent age at first calving (**A1C**). Survival age until first calving was either the age of death (true value, uncensored data) or the age of the last record found for weaning, first service, or first calving (censored value).

Data from each herd were analyzed separately because of the lack of independence and suspected differences in calving management practices (Barrier and Haskell, 2011). Linear mixed models were used to analyze birth weight (for calves holding WW records only), WW, GRW, and A1C. A generalized linear mixed model was applied for the analysis of NSERV, fitting a Poisson distribution and a logarithm link function. Sire and dam of the calf were used as a random model except for A1C in the CR herd, where convergence could be obtained with the sire of the calf only. Models were constructed for each herd and performance indicator by using a forward-stepwise technique in Genstat 11th Edition (2008; VSN International Ltd., Hemel Hempstead, UK) as described in Barrier and Haskell (2011). Birth characteristics were considered explanatory variables for the analysis and included year of birth, parity of the dam (primiparous or multiparous), season born (summer: April to September; winter: October to March), month of birth, birth weight, genetic group (select: animals selected toward greater milk solids; control: animals selected to be the rolling UK average), birth litter size (singleton vs. twins), and degree of birth difficulty (normal, moderate, high).

In the EDI herd, GRW was analyzed with birth year interacting with birth season, genetic group, birth litter size, and birth difficulty as fixed effects. Weaning weight was analyzed with genetic group, year of birth, month of birth, birth litter size, and birth difficulty as fixed effects and birth weight and age at weaning as covariates. The model included parity of the dam, birth litter size, genetic group, and birth difficulty as fixed effects. Only birth difficulty was included for analysis of NSERV. Age at first calving was analyzed including birth season interacting with year of birth and birth difficulty as fixed effects.

In the CR herd, GRW was analyzed with year of birth and birth difficulty as fixed effects and birth weight as a covariate. Weaning weight was analyzed with year of birth, birth litter size, and birth difficulty as fixed effects and birth weight and age at weaning as covariates. The model included parity of the dam, birth litter size, and birth difficulty as fixed effects.

The model used for analysis of NSERV included genetic group and birth difficulty. Analysis of A1C included year of birth interacting with month of birth as well as birth difficulty as fixed effects.

In the EDI herd, survival of the calves to weaning, first service, and first calving after birth difficulty (no assistance: n = 1099; moderate difficulty: n = 77; high difficulty: n = 61) was analyzed using Cox proportional hazards models in R 2.11.1 (2010; The R Foundation for Statistical Computing, Wien, AT). Hazard ratios >1 indicate higher mortality risks (lower survival) compared with no assistance, whereas values <1 indicate a lower risk (higher survival). Global significance of each fixed effect was assessed using a likelihood ratio test, which assumes that twice the difference of the log-likelihoods follows a chi-squared distribution (Collett, 2003). The model used for analysis included parity of the dam, calving year, calving season, genetic group, and birth difficulty as factors and birth weight (kg) as a covariate. In the present data set, birth litter size was highly confounded with parity of the dam because 93% of the twin calves (n = 86) were from multiparous dams. This means that birth litter size was accounted for by adjusting for parity and therefore was not included in the final model. Confirmation of this was obtained when replacing birth litter size by parity led to similar results. Descriptive data on survival to calving are presented for the CR herd because of the small size of the data set (no assistance: n = 418; moderate assistance: n = 27; high assistance: n = 6).

Live-born heifers with moderate difficulty had a 3-fold greater risk of dying before weaning (Table 1; $P < 0.05$) and before first service (Table 1; $P < 0.001$) in the EDI herd compared with heifers born without assistance. Survival to first calving was, however, not affected by the difficulty experienced at birth (Table 1; $P > 0.05$). In the CR herd, the survival rates of live-born calves born without assistance (n = 418) were 88.8, 82.3, and 77% at weaning, first service, and first calving, respectively. When born with moderate assistance (n = 27), their survival rates were 81.5, 74, and 74%. Calves born with high assistance (n = 6) had a similar survival rate of 66.7% at weaning, first service, and first calving.

Mortality rates in the live-born heifers after a difficult birth were higher both until weaning and up to their first service. The poorer survival of dystocial heifers beyond the first 2 d of life is in line with previous studies on dairy cattle (Wells et al., 1996; Lombard et al., 2007; Henderson et al., 2011). As opposed to previous studies that include calves born dead, this result was confirmed in live-born calves, even for moderate degrees of difficulty, and highlights long-term effect on survival of

Table 1. Hazard ratio of live-born heifer calves dying from birth to weaning and their 95% confidence intervals in the Langhill Farm herd (Edinburgh, UK), after birth difficulty, parity of the dam, season born, and genetic group

Item	Weaning	First service	First calving
Birth difficulty	*	***	NS
Normal (n = 1,099)	Ref.[1]	Ref.	Ref.
Moderate (n = 77)	2.9 [1.4; 5.9]	3.0 [1.7; 5.4]	1.6 [1.1; 2.5]
High (n = 61)	1.9 [0.9; 4.4]	1.4 [0.7; 2.7]	1.0 [0.6; 1.7]
Parity	NS	*	**
Primiparous (n = 349)	Ref.	Ref.	Ref.
Multiparous (n = 888)	0.9 [0.5; 1.4]	1.5 [1.0; 2.1]	1.5 [1.1; 1.9]
Birth season	NS	NS	***
Summer (n = 365)	Ref.	Ref.	Ref.
Winter (n = 872)	1.2 [0.7; 2.1]	0.9 [0.7; 1.3]	1.8 [1.4; 2.3]
Genetic group	NS	NS	***
Control (n = 482)	Ref.	Ref.	Ref.
Select (n = 755)	1.1 [0.7; 1.8]	1.3 [0.9; 1.8]	1.4 [1.1; 1.8]
Birth weight (n = 1,237)	***	***	***
	0.8 [0.8; 0.9]	0.9 [0.9; 0.9]	1.0 [0.9; 1.0]

[1]Ref.: reference level.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$, NS: $P > 0.05$.

the heifer. In the present study, it was surprising that increased risk of dying was not seen for the most severe cases of birth difficulty. This may be due to the lower statistical power in the highest degrees of birth difficulty preventing statistical significance. It cannot be fully excluded that some of the effects of birth difficulty could be attributed in part to being a twin calf. This is because of the necessary choice of including parity and not birth litter size in the multivariate statistical model because of the very high level of confounding between these effects. The higher prevalence of difficulty in twin births (Mee, 2008) was also verified in the present study. A larger data set may have helped to disentangle the effects of birth difficulty, birth litter size, and parity of the dam and also to take into account the effect of the calf's sire.

In the EDI herd, live-born calves that experienced moderate difficulty at birth were heavier at birth than calves that were not assisted or that experienced greater difficulty (Table 2; $P < 0.001$), but this was not seen in the CR herd (Table 2; $P > 0.05$). In both herds, weaning weights and growth rates to weaning did not differ between calves born without help and calves born with difficulty (Table 2; $P > 0.05$). This disagrees with previous studies in beef cattle (Bellows et al., 1988; Goonewardene et al., 2003). In beef cattle, weaning occurs at a later age, and a lower weaning weight in the offspring could be attributed to either calf factors (feeding intake and behavior, metabolism) or to the dam having lower milk production (Dematawewa and Berger, 1997; Mee, 2008; Barrier and Haskell, 2011) or reduced maternal care. However, an absence of effects of birth difficulty has been reported previously on the growth of dairy calves to 3 mo of age (Lundborg et

al., 2003) and to calving (Heinrichs et al., 2005). This is despite dystocial calves being more likely to suffer from respiratory diseases, at least during their first 4 mo of life (Wittum et al., 1994a; Lombard et al., 2007), and sickness being associated with decreased growth (Wittum et al., 1994b; Donovan et al., 1998). In addition, we observed no evidence in the present study that dystocial calves had subsequently impaired fertility as no effect of birth difficulty existed for the number of services needed to achieve pregnancy and the age at first calving in the EDI and CR heifer calves (Table 2; $P > 0.1$).

Similar performance in terms of growth to weaning and subsequent fertility as nulliparous animals suggest that birth difficulty had no apparent long-term effects on the performance of dairy heifers in this study. However, this would be ignoring the findings of previous studies that have reported greater health problems beyond weaning (Lombard et al., 2007) and lower lifetime milk production as adult cows (Heinrichs and Heinrichs, 2011). Furthermore, live-born heifers have poorer survival, as shown in this study, but also possibly up to their first calving (Henderson et al., 2011). It is possible that the most severely affected dystocial calves die early and that therefore only the less affected heifers, on which performance records were collected, remain in the herd. It could also be that good heifer management may have compensated for any sublethal effects, if they exist. The data collected as part of the present study did not allow such investigations.

It is important that this study highlights the dramatic effect of dystocia on the survival of the resulting heifer calves. Heifer mortality after birth, regardless of its causality, is a welfare concern and a direct economic

Table 2. Estimated means ± standard errors of birth weights, subsequent weaning weights (WW), growth rate to weaning (GRW), age at first calving (A1C), and back-transformed means [95% confidence interval] of the number of services to conception (NSERV) for heifer Holstein calves having experienced different degrees of birth difficulty (no assistance, moderate assistance, high assistance) in the EDI and CR herds[1]

Item	EDI herd				CR herd			
	No assistance	Moderate difficulty	High difficulty	P-value	No assistance	Moderate difficulty	High difficulty	P-value
GRW (g/d)	542.8 ± 10.1 (n = 1,017)	549.5 ± 16.9 (n = 66)	545.4 ± 17.1 (n = 53)	NS	440.3 ± 8.7 (n = 546)	444.6 ± 22.1 (n = 37)	374.0 ± 49.9 (n = 7)	NS
Birth weight (kg)	38.6 ± 0.4[b] (n = 1,017)	41.0 ± 0.6[a] (n = 66)	39.2 ± 0.7[b] (n = 53)	***	36.8 ± 0.6 (n = 546)	37.7 ± 0.9 (n = 37)	36.1 ± 1.9 (n = 7)	NS
WW (kg)	71.0 ± 0.6 (n = 1,017)	70.7 ± 0.9 (n = 66)	71.3 ± 0.9 (n = 53)	NS	62.4 ± 0.9 (n = 546)	62.7 ± 1.4 (n = 37)	58.3 ± 2.7 (n = 7)	NS
NSERV (count)	1.5 [1.4 to 1.6] (n = 649)	1.7 [1.4 to 2.1] (n = 42)	1.5 [1.2 to 2.0] (n = 36)	NS	2.0 [1.8 to 2.1] (n = 347)	1.9 [1.4 to 2.6] (n = 22)	1.8 [0.9 to 3.3] (n = 6)	NS
A1C (d)	753.7 ± 2.9 (n = 707)	748.4 ± 8.5 (n = 42)	758.8 ± 8.8 (n = 39)	NS	767.3 ± 12.4 (n = 319)	774.9 ± 18.2 (n = 20)	783.2 ± 28.7 (n = 5)	NS

[a,b]Within a row and within each herd, means with different superscripts differ ($P < 0.05$).
[1]Number of animals available for each analysis is given in parentheses. The EDI herd was reared at the Langhill Farm (Edinburgh, UK), and the CR herd was reared at the Crichton Royal Farm (Dumfries, UK).
***$P < 0.001$; NS: $P > 0.05$.

cost to the producer, but also a major impediment to the long-term economic sustainability of dairy systems. This is because heifers contribute to the renewal of the dairy herd but also deliver to the animals, producers, and industry genetic improvement for production and welfare traits. This study therefore emphasizes the importance of preventing dystocia not just from the point of view of the adult cow, but also from the perspective of the calf, to improve farm efficiency and calf welfare.

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