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Risk Factors for Dystocia and Perinatal Mortality in Extensively Kept Angus Suckler Cows in Germany

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Abstract: Dystocia and perinatal mortality are major animal health, welfare and economic issues in beef suckler cow production. The objective of this study was to identify risk factors for dystocia and perinatal mortality and to analyze the relationships of both traits to external pelvic parameters in extensively kept beef suckler cows. Calving ease and calf survival were recorded for 785 births on five Angus cattle farms in Germany. The prevalence of dystocia and perinatal mortality was 3.4% and 4.3%, respectively. A hierarchical model was used to predict dystocia and perinatal mortality. First-parity dams had a higher probability of dystocia ($p < 0.0001$) than later-parity ones. Increasing birth weight was associated with an increasing risk for dystocia ($p < 0.05$). The probability of perinatal mortality ($p < 0.0001$) was higher in assisted births than in unassisted births. Calves from first-parity dams had a higher risk ($p < 0.01$) of being stillborn than calves from dams in later parities. An increase in the length of the pelvis was associated with an increase in odds for perinatal mortality ($p < 0.001$). In conclusion, the study indicates that dystocia and perinatal mortality are mainly problems in first-parity suckler cows. Concerning the predictive value of external pelvic parameters, further research is necessary.

Keywords: dystocia; perinatal mortality; stillbirth; beef cattle; suckler cows; Angus; pelvic measurements

1. Introduction

Currently the share of suckler cows in the total cow population is 13.7% in Germany [1]. However, due to increasing consumer demands for economic sustainability, animal welfare and product quality, suckler cows are gaining importance in livestock farming [2]. One decisive factor for the efficiency of suckler cow cattle production, especially under extensive conditions on pasture, is complication-free calving since dystocia results in increased perinatal mortality [3–5] and decreased subsequent reproduction [6–8], which causes important economic losses in the suckler cow industry.

Generally, twin births are associated with more frequent calving difficulties and twin calves have a higher risk of stillbirth [9,10]. Concerning singleton calves, dystocia and perinatal mortality are affected by various genetic and non-genetic factors [11,12]. The probability of calves being stillborn is higher in assisted than in unassisted births [13,14].

In many studies, higher dystocia and stillbirth rates were reported in first-parity cows than in later-parity ones [15–17]. The differing prevalence among parities is mainly due to the greater extent of feto-maternal disproportion in primiparous dams. Hence, calf birth weight is more critical in heifers. Consequently, several attempts have been made to decrease calving difficulties and thus likewise perinatal mortality during first parturition. For instance, internal pelvimetry is widely used in beef cattle industries in the United States and Canada [18–20]. Measuring the internal pelvic area in order to predict dystocia and consequently culling heifers with small pelvises is discussed as being a useful tool for decreasing dystocia [20]. In recent years, however, studies on dairy cattle have concentrated on the relationships between externally measured pelvic parameters and both calving ease and calf survival [21,22]. For example, Johanson and Berger [21] documented an impact of external pelvic area on dystocia. Moreover, Gundelach et al. [22] reported an association between an externally measured length of the pelvis and perinatal mortality.

On the one hand, there is a lack of studies on dystocia and perinatal mortality in beef suckler cows kept extensively on pasture. In a study conducted by the LELF (Landesamt für Ländliche Entwicklung, Landwirtschaft und Flurneuordnung Brandenburg, engl. State Office for Rural Development, Agriculture and Consolidation of the German Federal State Brandenburg) [23] on functional traits of beef cattle, the influence of calf birth weight and sire of the calf on calving performance of beef cattle kept under extensive husbandry conditions in Germany was analyzed. In another German investigation by Brandt et al. [24] on the preweaning traits of some beef cattle breeds kept under similar conditions, the incidence of dystocia was determined. None of these studies analyzed the prevalence of perinatal mortality and its risk factors. However, especially in beef suckler cows that are kept under extensive conditions with limited surveillance during the grazing period complication-free calving without calf losses is important for animal welfare and economic reasons. On the other hand, there are also only a few studies on external pelvimetry in beef cattle. For instance, Johnson et al. [25] investigated the relationships between calving difficulties and external pelvic measurements in a small number of beef cattle cows and found none. In contrast, some authors reported an association between external pelvic parameters and both dystocia and perinatal mortality in dairy cattle [21,22]. Hence, there are indications that a relationship between external pelvic measurements, calving ease and calf survival might also exist in beef suckler cows. There are also indications that external pelvimetry might be of practical use in preventing dystocia and perinatal mortality in suckler cows.

The objectives of the present study were (1) to identify and evaluate risk factors for dystocia and perinatal mortality and (2) to analyze the relationships of both issues to external pelvic parameters in extensively kept Angus suckler cows in Germany.

2. Materials and Methods

2.1. Animals

The study was performed on five beef suckler cow farms (Farms A–E) in four regions of Germany from April 2015 until March 2017. The farms differed in herd size, ranging from approximately 25 to 270 breeding animals, including heifers, cows and sires. The breeds were Aberdeen and German Angus (a mixture of Aberdeen Angus bull with German dual-purpose breeds which was developed in the 1950s) with herd book registration.

The farms were located in four different regions of Germany. Farm A (65 m above sea level) was located in the North of Germany, Farm B (110m above sea level) and Farm C (400 m above sea level) were located in Central Germany and Farms D and E (both approximately 450 m above sea level) were located in Southern Germany. Farms B, D and E were certified organic farms. Farms A and C kept the herds at extensive stocking densities.

From spring to autumn (April to October), depending on weather and feeding conditions as well as individual farm management, the animals grazed on pastures in groups of varying number. During the grazing period no supplementary feeding was provided. In winter (November to March), the herds were housed in free stalls on four out of the five farms and on one farm they were kept outdoors with weather protection being provided. The animals were fed a diet based on grass silage or hay during the winter months.

Natural mating was used for all herds. The calving seasons differed among farms. On all farms, an autumn calving season was established. Farms A and B had an additional calving season in spring and winter, respectively. On Farm A, breeding periods were in winter (January to February) and spring (April to May) and on Farm B, breeding periods were in winter (December to January) and summer (July to August). On Farms C, D and E, breeding period was only in winter (December to January).

2.2. Methods

The investigations were conducted under field study conditions. All of the animals were housed in accordance with the EU (European Directive 2008/120/EC) and national law (Tierschutzgesetz, Tierschutz-Nutztierhaltungs-Verordnung). In compliance with European Directive 2010/63/EC Article 1 5. (f), the present study did not imply any invasive procedure or treatment to the animals. No pain, suffering or injury was inflicted on the animals during the study. The study was approved by the animal welfare office of the University of Veterinary Medicine Hannover, Foundation.

Calving ease and calf survival were documented by the herd managers using a modified version of scales recommended by the German Cattle Breeders' Federation [26]. Calving ease was scored on a scale ranging from 1 to 4. The scores were assigned as follows: 1 = easy calving (spontaneous, unassisted), 2 = calving with slight assistance (manual pull of one person), 3 = calving with moderate assistance (manual pull of two or more people and/or mechanical extraction, and/or veterinary assistance without surgery), or 4 = calving with surgery (Caesarean section or fetotomy). Calf survival was classified as 1 = alive or 2 = dead (stillborn, having died during parturition, or within 48 h after parturition). All farms acted according to the principle of the least possible intervention at calving.

Additionally, the following data were recorded for each calving: number of calves born (singleton calf, twin calves), date and location of calving (pasture or barn) as well as breed (Aberdeen or German Angus) and lactation number of dam. In accordance with previous studies on dairy cattle, pelvic parameters, i.e., length of pelvis, position of pelvis, distance between hip bones and distance between ischial tuberosities, were externally measured by one single observer within eight weeks before or after the beginning of the farm-specific calving periods [21,22]. For measuring the distance between hip and ischial tuberosities, a self-constructed caliper-like device was used. Definitions of the various parameters are given in Table 1.

Table 1. Definitions of pelvic parameters derived from the dams.

Parameter	Unit	Definition
Length of pelvis	cm	Distance between the cranial edge of the Tuber coxae and the caudal edge of the Tuber ischiadicum
Position of pelvis	cm	Distance between two horizontal lines at the height of the Tuber coxae and the Tuber ischiadicum
Distance between hip bones	cm	Distance between the lateral edges of the Tuber coxae
Distance between ischial tuberosities	cm	Distance between the lateral edges of the Tuber ischiadicum

Furthermore, the following measurements were derived from the calves within 24 h after parturition by the herd managers who had been instructed in advance: birth weight, body length and cannon bone circumference [27]. On Farm C, D and E only one person was responsible for the calving management. On Farm A and B two herd managers were employed but all measurements from the calves were taken by the same one on each farm. For measuring the birth weight, farm-owned calibrated scales were used. The body length was measured as a body-aligned curved distance. Both body length and cannon bone circumference were measured with calibrated flexible measuring tapes. The data was checked for plausibility. Definitions of the various parameters are shown in Table 2. Additionally, the sex of the calf was documented.

Table 2. Definitions of parameters derived from the calves.

Parameter	Unit	Definition
Body length	cm	Distance along vertebral column between the cranial angle of the Scapula and first caudal vertebra
Cannon bone circumference	cm	Circumference of cannon bone measured at the narrowest point of the metacarpus

For statistical analysis, the data were grouped into 1 = unassisted calving, consisting of births with score 1, and 2 = assisted calving, including births with scores 2 to 4, as information on the extent of calving assistance was not available for all cases of dystocia. Moreover, cows were grouped according to their parity into 1 = primiparous and 2 = multiparous cows. The season of calving was classified as spring (March to May), summer (June to August), autumn (September to November) and winter (December to February).

2.3. Statistical Analysis

All results were processed with Excel (Microsoft Corporation, Redmond, WA, USA) and statistically analyzed with SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). At first, the impact of twin pregnancies on dystocia and perinatal mortality was investigated by calculating absolute and relative frequencies as well as odds ratios (OR) with 95% confidence interval (95% CI). Afterwards, the twin births (n = 34) and all parturitions with missing information on the birth weight and sex of the calf (n = 6) were omitted from the data set. Furthermore, as no information on the gestation length was available due to natural service, parturitions with birth weights that were more than two standard deviations away from the mean (n = 17) were removed from the data set to exclude premature born calves.

Various environmental, fetal as well as maternal factors were considered to be potentially valuable predictors for dystocia and/or perinatal mortality. Breed and parity of dam as well as sex and birth weight of calf were chosen since they were the most frequently reported factors having an impact on calving ease and calf survival in literature [11,12]. Season and location of calving were selected because possible effects of environmental conditions on dystocia and perinatal mortality should be detected. Calf size parameters other than birth weight were tested to determine if one of them was more suitable than birth weight for predicting the investigated traits. The different external pelvic parameters of the dam were selected since there are some indications in literature that they might be of practical use in prediction and prevention of dystocia and perinatal mortality. Furthermore, these external traits are easy and non-invasive to measure in comparison to internal pelvic measurements. All factors are given in Table A1 in the Appendix A.

The dependent variables calving ease (1 = assisted, 2 = unassisted) and calf survival (1 = dead, 2 = alive) were analyzed using mixed linear models (PROC MIXED). The five beef suckler cow farms were included as a random variable and cows were nested within these farms since they are genetically related and managed similarly (i.e., nutrition, climate). Odds ratios were calculated to estimate significant effects on dystocia and perinatal mortality. The level of significance was set at $p < 0.05$. To check whether the data did not conflict with assumptions made by the final model, the Hosmer-Lemeshow goodness of fit test was performed.

The final model for dystocia was as follows (Equation (1)):

$$y_{ijklm} = \mu + BW_i + P_j + SC_k + F_l + C_m\ (F_l) + e_{ijklm} \quad (1)$$

where y_{ijklm} is the trait, μ the overall mean, BW_i the fixed effect of birth weight of calf, P_j the fixed effect of parity of dam, SC_k the fixed effect of season of calving, F_l the random effect of the farm, C_k (F_l) the cow nested within the farm and e_{ijklm} the random residual effect.

For perinatal mortality, the data were analyzed with the following model (Equation (2)):

$$y_{ijklm} = \mu + CE_i + P_j + PL_k + F_l + C_m\ (F_l) + e_{ijklm} \quad (2)$$

where y_{ijklm} is the trait, μ the overall mean, CE_i the fixed effect of type of calving ease, P_j the fixed effect of parity of dam, PL_k the fixed effect of length of pelvis, F_l the random effect of the farm, C_m (F_l) the cow nested within the farm and e_{ijklm} the random residual effect.

3. Results

In the experimental period, 825 parturitions were recorded. Of these, 4.1% (n = 34) were twin births so that a total number of 859 calves were born. The dystocia rate among single pregnancies was 3.8% (n = 33) and among twin pregnancies 8.8% (n = 3). Within 48 h after parturition, 5.3% (n = 42) of singleton calves and 33.8% (n = 23) of twin calves died. Of the twin pregnancies, 18 resulted in two living calves, nine in one living as well as one dead calf and seven in two stillborn calves. Twin calves had a 9.1 times higher probability of perinatal mortality than singleton calves (OR = 9.115; 95% CI: 5.049–16.455).

After editing, the data set contained 768 single parturitions and the prevalence of dystocia and perinatal mortality were 3.4% and 4.3%, respectively. The incidence of dystocia was 3.4% for both female and male calves. The prevalence of perinatal mortality for male and female calves were 3.9% and 4.8%, respectively. Of the dead calves, 78.8% died pre- or intrapartum and 21.2% died within 48 h after parturition. Absolute and relative frequencies for calving ease and calf survival and means and standard deviations of calf size parameters both in relation to parity of the dam are given in Tables 3 and 4, respectively.

Table 3. Absolute and relative frequencies for calving ease and calf survival in relation to parity of the dam.

Trait	Level	Primiparous	Multiparous	Total
		n = 156	n = 612	n = 768
Calving ease	Unassisted	141 (90.4%) [1]	601 (98.2) [2]	742 (96.6%) [3]
	Assisted	15 (9.6%) [1]	11 (1.8%) [2]	26 (3.4%) [3]
Calf survival	Alive	143 (91.7%) [1]	592 (96.7%) [2]	735 (95.7%) [3]
	Dead	13 (8.3%) [1]	20 (3.3%) [2]	33 (4.3%) [3]

[1] percentage of total number of primiparous cows, [2] percentage of total number of multiparous cows, [3] percentage of total number of cows.

Table 4. Means and standard deviations of calf size parameters in relation to parity of the dam.

Calf Size parameter	Parity	N [1]	Means	SD [2]
Birth weight (kg)	Primiparous	156	34.41	3.92
	Multiparous	612	36.39	3.93
	Total	768	35.98	4.00
Body length (cm)	Primiparous	76	53.69	4.27
	Multiparous	306	56.32	4.51
	Total	382	55.8	4.58
Cannon bone circumference (cm)	Primiparous	76	11.65	0.72
	Multiparous	306	11.98	0.90
	Total	382	11.92	0.88

[1] number of observations, [2] standard deviation.

3.1. Dystocia

The hierarchical model for dystocia (shown in Equation (1)) included parity of the dam, birth weight of calf as well as season of calving as fixed effects. The p-values and F-values for these parameters are given in Table 5. Table 6 shows the OR estimates for the significant effects of parity of the dam and birth weight of the calf.

Table 5. *p*- values and F- values of parameters in the hierarchical model for dystocia.

Parameter	*p*-Value	F-Value
Parity of dam	<0.0001	15.47
Birth weight of calf	0.0205	5.43
Season of calving	0.6703	0.52

Table 6. Odds ratio estimates for effects in the logistic regression model for dystocia.

Effect	Level or Unit	Comparison	OR [1]	95% CI [2]
Parity of dam	1 = primiparous 2 = multiparous	1 vs. 2	9.672	4.033–23.195
Birth weight of calf	Kg	Linear trend	1.279	1.137–1.438

[1] OR = odds ratio, [2] CI = confidence interval.

First-parity cows had 9.7 times higher odds for dystocia than cows in later parities. Furthermore, a 1 kg increase in calf birth weight corresponded to an increase of 27.9% in dystocia.

3.2. Perinatal Mortality

The hierarchical model for perinatal mortality (shown in Equation (2)) included the parameters calving ease, parity of dam and length of pelvis. In Table 7 the p-values of these parameters are shown. The OR estimates for the significant effects of calving ease, parity of dam and length of pelvis are given in Table 8.

Table 7. *p*-values and F-values of parameters in the hierarchical model for perinatal mortality

Parameter	*p*-Value	F-Value
Calving ease	<0.0001	30.76
Parity of dam	0.0093	6.93
Length of pelvis	0.0007	11.89

Table 8. Odds ratio estimates for effects in the logistic regression model for perinatal mortality.

Effect	Level or Unit	Comparison	OR	95% CI
Calving ease	1 = assisted 2 = unassisted	1 vs. 2	12.835	3.199–51.497
Parity of dam	1 = primiparous 2 = multiparous	1 vs. 2	5.047	1.359–18.743
Length of pelvis	Cm	Linear trend	1.268	1.100–1.462

The probability of perinatal mortality was 12.8 times higher in assisted than in unassisted births. Furthermore, calves from first-parity dams had a 5.0 times higher risk of being stillborn than calves from dams in later parities. Concerning length of pelvis, a 1 cm increase in the length of the pelvis corresponded to an increase of 26.8% in perinatal mortality.

4. Discussion

Dystocia and perinatal mortality are major animal health and welfare problems as well as economic issues of beef and dairy cattle production in different parts of the world [4]. The dystocia prevalence within the present investigation was comparable to the prevalence of 3.0% and 3.3%, respectively, found by other authors in the Angus breed [4,6]. One possible explanation for this could be the varying definition of dystocia among these studies. In the present investigation, calving ease was classified according to the requirement of calving assistance during parturition, whereby two categories, assisted or unassisted, were created. The assisted category included births that required slight to moderate assistance as well as surgical intervention. The unassisted category solely consisted of births requiring no assistance at all, whereas in other studies this category also contained births where slight assistance had been given. Using comparably defined classes, Berger et al. [16] reported similar dystocia rates of 4.5% and 3.7%, respectively, in Angus cattle, supporting the present findings, while Brandt et al. [24] found a higher rate of 7.7% in German Angus cattle.

In literature, perinatal mortality is mostly defined as death of a calf just before, during, or within 24 h after parturition. In the present study, however, calves that had died within 48 h after birth were also included in the perinatal mortality category as recommended by the German Cattle Breeders' Federation [26]. Consequently, these diverging definitions might be a possible explanation for the higher prevalence of perinatal mortality found in the present investigation compared with the prevalence of 2.7% and 2.1%, respectively, reported by previous authors [4,16].

The results of this study on risk factors for dystocia support the findings of Berger et al. [16] in Angus cattle. In agreement with several authors, first-parity dams were more likely to experience a difficult calving in relation to cows in later parities [21,28,29]. Furthermore, calving ease was associated with calf birth weight. Consistent with other studies, an increase in birth weight corresponded to increasing occurrence of dystocia [6,16,21,29,30]. Several studies reported that the effects of parity and calf birth weight on calving ease are for the most part due to the disproportion of the pelvic dimensions of the dam and the size of the calf [11,31]. According to a review on prevalence and risk factors for dystocia in dairy cattle by Mee [31], feto-pelvic disproportion is the main reason for dystocia in heifers because of their physical immaturity. First-parity dams have incompletely developed and thus smaller pelvises than dams in later parities. In older heifers, however, over-condition and uterine inertia also contribute to the higher dystocia prevalence [31]. Calf size, usually represented by birth weight, is the second factor having an impact on the feto-pelvic ratio apart from pelvic dimensions. Calf birth weight is described as being mostly influenced by the length of gestation [31,32]. Other factors reported to be associated with birth weight are parity of dam, sex of calf, dam and sire breed, dam weight, dam nutrition during final trimester and the calving season [8,21,31,33].

The risk factors for perinatal mortality were similar to those for dystocia. Calf survival was associated with the effects of calving ease, parity of dam and length of pelvis. Of these effects, calving ease was the factor having most impact on calf survival. The greater likelihood of perinatal mortality following dystocia corroborates other studies [21,29,34,35]. On the one hand, severe dystocia with an elongated calving process can immediately result in calf death during parturition because of prolonged hypoxia. On the other hand, calving difficulties affect the long-term survival of calves since acidosis following oxygen deprivation subsequently affects the function of vital organs and thus overall vitality [36]. Moreover, internal injuries resulting from inappropriate calving assistance or impaired thermoregulation might also contribute to increased calf mortality [3,5]. Consistent with other studies, the likelihood of perinatal mortality occurring was greater in first-parity dams than in later-parity ones [4,16,21,29,37]. One possible explanation for this is the greater probability of dystocia in primiparous cows than in multiparous ones, since calf survival and calving ease were found to be related traits, supporting the findings of Berger et al. [16] in Angus cattle. Likewise, contrary to the findings of Johanson and Berger [21] in Holstein cattle, the length of the pelvis did affect calf survival. Gundelach et al. [22], however, also reported an association between the length of pelvis and calf survival, but only in the univariate analysis and in dairy cattle.

In agreement with other recent studies, most external measurements, except for the length of the pelvis, neither contributed to dystocia nor to perinatal mortality [25,38]. Once again, this was in contrast to results of Johanson and Berger [21] who reported an association between external measured pelvic area and calving ease in dairy cattle, concluding that external measurements might be of practical value when predicting dystocia as a possible substitute for internal pelvimetry. During the last decades, internal pelvic measurements have been widely used in beef cattle industries to decrease calving difficulties in heifers. Opinions concerning the value thereof, however, vary in literature. Several studies indicate that measuring the internal pelvic area and culling those heifers with extremely small pelvises before breeding is a useful method for decreasing dystocia occurrence during first parturition [19,20,25,30,39]. In contrast to this, the findings of Van Donkersgoed [40] demonstrate that internal pelvic measurements due to their inaccuracy and imprecision are of no practical use. In the authors' opinion, the invasiveness of internal pelvimetry is disproportionate to its potential benefit. Additionally, some authors consider selecting sires by birth weight to be more effective in reducing dystocia prevalence [19,20,41].

Consistent with other investigations, calf sex was neither associated with calving ease nor calf survival [10,33]. In contrast to this, some authors reported a higher probability of dystocia in births of male calves as opposed to female ones [8,16,21]. Moreover, most authors stated that bull calves were more likely to die than heifer calves [3,4,14]. In literature, both effects are mainly attributed to the birth weight differences between calf sexes. Male calves tend to have higher mean birth weights than female calves. Increasing birth weight corresponds to an increasing likelihood of dystocia, which, in turn, results in an increasing likelihood of perinatal mortality. Consequently, bull calves have a higher risk of both dystocia and perinatal mortality [4]. Therefore, an effect of sex might have been observed in the present study if birth weight had been excluded from statistical analysis.

In contrast to the present results, some authors reported a seasonal effect on calving ease and calf survival in Holstein dairy cattle. In several investigations, a decreasing risk of dystocia was found in summer compared with colder seasons [17,21]. One possible reason for this observation might be higher temperatures in summer. At higher ambient temperatures, the blood flow is due to thermoregulation diverted from visceral organs to thermoregulating organs like the skin. This physiological mechanism results in reduced uterine blood flow with decreased nutrient uptake to the fetus and thus decreased birth weights and risk for dystocia [19,42]. Concerning perinatal mortality, there is inconsistency in the reports. Silva del Río et al. [10] documented a higher probability of stillbirth in colder seasons, whereas Meyer et al. [13] observed an opposite trend. One possible explanation for this could be varying average daily temperatures in winter because of different study sites. The study by Silva del Río et al. [10] was performed in Minnesota, USA, whereas the investigations by Meyer et al. [13] were conducted in seven Midwestern United States (Iowa, Kansas, Missouri, Nebraska, North Dakota, Oklahoma and South Dakota). Generally, average daily temperatures in winter are lower in Minnesota than in the Midwestern United States. Therefore, the reported higher prevalence of stillbirth in winter by Silva del Río et al. [10] is probably resulting from an also higher prevalence of dystocia because of increased birth weights due to colder ambient temperatures. One possible explanation for the higher probability of stillbirth in summer observed by Meyer et al. [13] could be less intensive calving surveillance during grazing period causing a higher rate of dystocia [11]. All other environmental factors that were investigated were also not associated with calving ease or calf survival.

The study provides an insight into the current situation regarding prevalence and risk factors for dystocia and perinatal mortality in extensively kept Angus suckler cows in Germany. Although the investigations were performed at different study sites in various regions of Germany, the results cannot be generalized across Germany to reduce dystocia and perinatal mortality amongst Angus suckler cows due to the small number of observations. Furthermore, the farms were not randomly selected, but participated on a voluntary basis possibly influencing the outcome of the study because the herd managers were more motivated to achieve positive results regarding calving ease and calf survival.

5. Conclusions

In conclusion, dystocia and perinatal mortality are related multifactorial complexes. The present study on extensively kept Angus cattle indicates that both issues are mainly problems in first-parity beef suckler cows. According to the results, calf birth weight seems to be a crucial factor for calving ease. In particular for heifers, sires inheriting low birth weights should be used to prevent dystocia and thus also perinatal mortality. Concerning the predictive value of external pelvic measurements, further research on a broad database is necessary.

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Appendix A

Table A1. Factors considered to be potentially valuable predictors for dystocia and/or perinatal mortality.

Factors
Environmental factors
Year (2015–2017)
Farm (1–5)
Season (spring, summer, autumn or winter)
Location (pasture or barn)
Fetal factors
Sex (male or female)
Birth weight (kg)
Body length (cm)
Cannon bone circumference (cm)
Maternal factors
Breed (Aberdeen or German Angus)
Parity (primiparous or multiparous)
Length of pelvis (cm)
Position of pelvis (cm)
Distance between hip bones (cm)
Distance between ischial tuberosities (cm)
Calving ease (unassisted or assisted)

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