Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Department of Animal breeding and Genetics

Dystocia in Swedish beef cattle

– Effects of different scoring systems on the genetic evaluation

Kalvningssvårigheter hos svenska nötköttsraser – Påverkan på avelsvärderingen av olika graderingssystem

Filip Nilsson

Master's Thesis • 30 credits
Agricultural Science programme – Animal Science
Uppsala 2019

– Dystocia in Swedish beef cattle – Examination of different genetic evaluations

Kalvningssvårigheter hos svenska nötkreatur, köttraser – Utvärdering av olika genetiska avelsvärderingar

Filip Nilsson

Supervisor:	Susanne Eriksson, Dept. of Animal Breeding and Genetics, Swedish University of Agricultural Sciences
Assistant supervisor:	Freddy Fikse, Växa Sverige
Examiner:	Erling Strandberg, Dept. of Animal Breeding and Genetics, Swedish University of Agricultural Sciences

Credits:	30 credits
Level:	Advanced
Course title:	Master thesis in Animal Science
Course code:	EX0872
Programme/education:	Agricultural Programme, Animal Science
Course coordinating department:	Department of Animal Breeding and Genetics
Place of publication:	Uppsala
Year of publication:	2019
Cover picture:	Filip Nilsson
Online publication:	https://stud.epsilon.slu.se
Keywords:	Swedish beef cattle, beef breeding, normal score, genetic evaluation, residuals

Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science
Department of Animal Breeding and Genetics

Abstract

In Swedish beef cattle breeding, the genetic evaluation comprises calving traits, carcass traits and growth traits. For the calving traits stillbirth, birth weight and dystocia severity grade are recorded. The genetic evaluation for dystocia is divided into four traits; maternal and direct effect when the mother is a primiparous cow, and maternal and direct effect when the mother is a multiparous cow.

The system for reporting the grade of dystocia changed in May 2012 from a three-graded scale to a four-graded scale. The distribution of the dystocia grades became markedly different, which affected the breeding values in a way that several extremely low values have occurred.

This report examines different genetic evaluations with alternative normal scores instead of the old scores corrected for heterogeneous variance. Also some genetic correlations that had been put to zero to avoid extremely low breeding values were again added to the genetic evaluation to examine their effect on the breeding values.

In the current reporting system there are examples of negative breeding values, while in the old reporting system the breeding values were not that extreme. The breeding values seem to be more normally distributed when using the transformed normal scores compared to the old scores. There are also less extremely low breeding values. When adding the genetic correlations between the traits, the breeding values changed a little bit. Overall the results indicate that the genetic evaluation is more influenced by changes in the scores system than by the genetic correlation.

Sammanfattning

I köttaveln på nötkreatur i Sverige avelsvärderas djuren för kalvningsegenskaper, slaktkroppsegenskaper och tillväxtegenskaper. För kalvningsegenskaper är det två egenskaper som ingår i avelsvärderingen; födelsevikt och kalvningssvårighet. Avelsvärderingen för kalvningssvårigheter är uppdelad på fyra egenskaper, maternell effekt då modern är förstakalvare, direkt effekt då modern är förstakalvare, maternell effekt då modern är en äldre ko, och direkt effekt då modern är en äldre ko.

Rapporteringssystemet för kalvningssvårigheter ändrades i maj 2012 från en tregradig skala till en fyrgradig. Fördelningen mellan de rapporterade klasserna för kalvningssvårighet ändrades markant, vilket påverkade avelsvärdena så att avelsvärdena för en del djur blev extremt låga.

Denna rapport utvärderar olika sätt att hantera olika grader av kalvningssvårighet i avelsvärderingen med alternativa så kallade ’normal scores’ istället för de värden som används idag tillsammans med korrektion för heterogen varians. Några genetiska korrelationer som tidigare har satts till noll, på grund av de extremt låga avelsvärdena, återinfördes i denna rapport för att utvärdera deras påverkan på avelsvärdena.

Dagens rapporteringssystem och avelsvärdering ger upphov till en del negativa avelsvärden, medan det med det gamla rapporteringssystemet inte fanns lika extrema avelsvärden. Avelsvärdena verkar vara mer normalfördelade när man använder de transformerade ’normal scores’ jämfört med de värden som används idag. Det ger dessutom mindre extremt låga avelsvärden. När korrelationerna återinfördes så ändrades avelsvärdena något. Överlag indikerar resultaten att avelsvärderingen påverkas mer av om ’normal scores’ används än av om dessa korrelationer utelämnas eller inte.

Table of contents

1 Introduction

In the period September 2017 to August 2018 (milk recording year 2018), 0.8% of the calves from multiparous cows and 2.3% of the calves from primiparous cows in beef breeding herds were born with some kind of dystocia (Växa Sverige 2019). Dystocia is often defined as the need for assistance at a parturition. Different classes with different severities are used when reporting dystocia, where a higher number usually means a more severe parturition (Meijering 1984). In Sweden dystocia is measured in 4 grades, ranging from 11-14 where 11 is the easiest calving and 14 is the most difficult. The grades are further explained in chapter 1.3.

It is economically very important for a farmer with suckler cow production to have as many surviving calves as possible. To have an easy calving and low frequency of dystocia is therefore of great importance. Calves are the main production in suckler herds, which means that a cow's whole year production is lost if her calf dies (Jamieson *et al*. 2010). Due to the fact that the calf is the main production in a suckler cow herd, low fertility and/or high calf mortality directly affects the economy. Dematawena & Berger (1997) showed economic consequences of dystocia regarding production losses, fertility problems and losses of calves and cows. In beef suckler production the most important of the above mentioned traits are calf survival and cow fertility.

This report is limited to investigation of two breeds, Charolais and Simmental. Charolais is the numerically largest beef breed in Sweden, with 3,312 calvings from multiparous cows and 956 calvings from primiparous cows in milk recording year 2018. Simmental is the numerically third largest beef breed in Sweden with 1,614 calvings from multiparous cows and 515 calvings from primiparous cows. Simmental is the numerically largest beef breed when it comes to the use of AI (artificial insemination) from beef bulls on all cattle breeds in Sweden. The number of inseminations with Simmental bulls adds up to a total of 14,192 inseminations in milk recording year 2018, which corresponds to 2.6% of all inseminations. Charolais is the numerically fourth largest beef breed in terms of use of AI in Sweden, with a total of 9,326 inseminations from Charolais bulls on all cattle breeds in Sweden in milk recording year 2018, which corresponds to 1.7% of all inseminations (Växa Sverige 2019).

1.1 Swedish beef breeding

Växa Sverige is the official breeding organization in Sweden for the 9 numerically largest beef breeds; Aberdeen Angus, Blonde d'Aquitaine, Charolais, Hereford, Highland Cattle, Limousin, Simmental, Galloway and Chianina. They are responsible for the beef recording scheme and the genetic evaluation of these beef breeds in Sweden (Växa Sverige 2017a).

Every year around 170 bulls are performance tested at a testing station and thereafter the best half are sold to beef breeding farms. Each year a total of 1-2 bulls are selected to serve as AI-bull. What breed(s) that are selected depends on the demand and the stock of AI-doses of the different breeds. Purebred beef bulls are also used in both beef and dairy production herds. Those production herds rely on crossbreeding between dairy and beef breeds or between different beef breeds (Eriksson *et al*. 2007).

The traits that are recorded are calving traits, fertility, weights and carcass traits. Calving traits are compulsory to record. Included in calving traits are stillbirth and 4 different classes of easy calving ranging from easy calving to difficult calving with veterinarian help. For a calf to be considered stillborn it has to be dead when born, or die within 24 hours after parturition (personal communication Emma Carlén, Växa Sverige, 2018). The weights that are recorded are birth weight, which has to be recorded within 4 days after birth, weaning weight (200-day weight), which has to be recorded between 150 to 250 days of age and yearling weight (365-day weight), which has to be recorded between 325 to 425 days of age. The heifers can also be weighed at 550 days of age. For the carcass traits the carcass weight, fleshiness and fatness grades are recorded. Those are recorded at the commercial slaughterhouses and reported to the beef recording scheme. The best animals are used for breeding; thereby the information on carcass traits of young animals is limited, especially for heifers (Eriksson *et al*. 2007).

The main goal in beef breeding has always been improved growth traits. Another important aspect is to keep a constant average birth weight over the years to avoid increased calving problems (Eriksson *et al*. 2007). The genetic evaluation for beef breeds in Sweden is done with a linear animal model for growth traits since 2000. Somewhat later, also carcass and calving traits were added. For calving traits there is only one trait for which official breeding values are published, calving performance, dystocia, for primiparous cows. For this trait the heritability has been shown to be high enough, which is not the case for the other calving traits. The direct effect for dystocia is included in an index called FIX (födelseindex), which is an index for birth performance. The maternal effect for dystocia is included in an index called MIX (modersindex), this index also includes the maternal effect for 200-day weight. These two indexes take breeding values as well as economic weightings for the traits into account. Both maternal and direct genetic effects are also evaluated for birth weight and weight gain between birth and weaning. For post weaning gain only direct effects are evaluated. The carcass traits carcass weight, fleshiness and fatness grades are measured on young bulls. These traits are evaluated together with birth weight and weaning weight in the genetic evaluation (Eriksson *et al*. 2007).

1.2 Causes for dystocia

The causes for dystocia in cattle have been reviewed by Price & Wiltbank (1978) and Meijering (1984). There may be different reasons why dystocia occurs. The major cause of dystocia is often agreed to be the feto-pelvic incompatibility, which means that it is affected by the calf size and the pelvic dimensions of the cow. The sex of the calf affects the rate of dystocia in cattle, because males are heavier (and larger) at birth than females are. The size of the calf, and thereby also the severity of dystocia, is affected by how long the gestation period is. Another factor that affects the calf size is the choice of breed of the calf's father; fast growing breeds tend to give calves that are heavier at birth. The choice of bull that is used on the cows can also influence the calf size in other ways. One is considering the heterosis effect, where calves that are crossbred are heavier at birth. A high level of inbreeding instead decreases the birth weight of the calf. The calf size also increases when the age of the dam increases. Another cause for dystocia is malposition or posterior presentation at calving, which is only the case for 2-6% of all calvings. However, malpositioned calves make a high percentage of all the dystocias that call for veterinarian help (20-40%) (Meijering, 1984). Management factors can also affect the rate of dystocia, for example the nutritional value in the feed can alter the calf size, dystocia and perinatal mortality.

1.3 Recording of dystocia

Today's system for reporting of dystocia in Sweden uses a scale of 4 categories. The categories to choose among when reporting are: easy without help (11), easy with help (12), difficult without veterinarian help (13) and difficult with veterinarian help (14). Other options that the farmer can report are: data missing (15), abortion (8) and early calving (9). The previous system, which was replaced in 2012, had 3 different choices when reporting. Those were easy calving (1), normal calving with help (2) and difficult calving with help from at least 2 people (3). In addition, the farmers could also report malposition, data missing, abortion and early calving. The previous system with the three categories is hereafter referred to as the old system, and the current system with four categories is hereafter referred to as the new system.

A problem with the new system is that there is no class for reporting malposition. This has led to some confusion for the farmers about how to report malposition. The correct way is to try to imagine how the calving event should have gone if the calf was correctly positioned and report that. Unfortunately, this information has not reached the farmers fully and it is also quite difficult to estimate how the calving should have proceeded if the calf was normally positioned. Some of the calvings where the calves were malpositioned have been incorrectly reported as difficult with veterinarian help (14). This makes the breeding value very low for those cows due to the malposition of the calf (Personal communication Emma Carlén, Växa Sverige, 2018).

The distribution of recordings in the different classes in the new system did not turn out as expected. A very big part of the calvings (94%) from May 2012 until November 2018 has been reported as easy without help (11), while a very small part (0.35%) has been reported as difficult with veterinarian help (14). This uneven distribution, and big difference in the distribution between the old and the new system, causes problems in the genetic evaluation; the animals with reported calving difficulty code 14 get extremely bad breeding values for the calving traits. The breeding values for those cows should be low, but as it is now they seem to be even lower than they should be. The recorded codes are translated into assigned values for the genetic evaluation, and a correction is made to account for heterogeneous variances in the old and new system. This correction has further increased the phenotypic values used for animals with code 14 in the new system. Attempts have been made to fix this problem by lowering the assigned value that the dystocia grades are translated to. This attempt has made it somewhat better but unfortunately the problem has not been totally solved. To deal with this problem, some genetic correlations have been set to zero. This means that all traits (especially for the multiparous cows) are not used in the genetic evaluation because they would make the low breeding values even lower. In conclusion, there are problems that have occurred when changing the reporting system for dystocia, which mainly can be seen as very low breeding values. In addition, some available information is not used in today's genetic evaluation because they further increase the already low breeding values.

1.4 Aim and hypothesis

The aim of this study was to learn more about the effect of handling data on dystocia in different ways in the genetic evaluation, and to find out if the current system could be improved. Therefore, I compared different configurations of genetic evaluations of dystocia in Swedish beef cattle. The comparisons included different types of scores assigned for phenotypes recorded in the Swedish beef breeding scheme both until May 2012 with a three-graded scale and thereafter using the four graded scale. In addition, the effect of including or excluding correlations between some breeding values was evaluated. The hypothesis was that an inclusion of normal scores instead of the scores used today with heterogeneous variance would reduce the extremely low breeding values. We expected that the normal scores with different frequencies for different animal categories would better fit the distribution of reported dystocia grades and further decrease the extremely low breeding values. Further, we expected that the inclusion of genetic correlations would change the breeding values somewhat due to the inclusion of more information, but not very much because there are less extreme breeding values compared to the scores used today.

2 Material and Methods

2.1 Genetic evaluation

2.1.1 Threshold value

Calving ease is considered to be a discontinuous trait, also called a threshold trait. This is different from a continuous trait in that it has distinct classes, which are phenotypically different. In Sweden there are currently 4 different classes of dystocia; easy calving without help, easy calving with veterinarian help, difficult calving without help and difficult calving with veterinarian help. The idea behind a discontinuous trait and its inheritance is that the trait is based on an underlying continuous trait (liability), which has one or several thresholds that can be phenotypically measured and separated. For example, when a cow is giving birth, the level of ease can differ between different calvings. However, there is a threshold above which the calving gets difficult to the point that the farmer calls the veterinarian for help, and that point is the threshold for a different class. The idea that there is an underlying continuity can be utilized to treat threshold traits as continuous variables, without big penalties in the estimated breeding values (Falconer & Mackay 1996). This is the case for calving ease in Sweden: it is treated as a continuous trait in the breeding program. Another way to deal with threshold traits is to apply normal scores. This is done by what is called normal score transformation, which means that the phenotypes (classes) are transformed with the different frequencies taken into account onto the undergoing liability scale to get closer to a standard normal distribution.

2.1.2 Model

The model used in the genetic evaluation for dystocia in Swedish beef breeds is a multi-trait linear animal model. Best Linear Unbiased Prediction (BLUP) is applied in the evaluation. The model for dystocia looks like this:

$$y = \mathrm{Sex} + \mathrm{Herd} * \mathrm{Year} + \mathrm{Age\ of\ dam} + \mathrm{Dam\ PE} + \mathrm{Dam\ M} + \mathrm{Animal} + \mathrm{Residual}$$

Where Sex, Herd*Year and Age of dam are fixed effects, Dam PE is the random permanent environmental effect of dam, Dam M is the random maternal genetic effect, Animal is the random direct genetic effect, and Residual is the random residual effect.

Birth weight is used as an indicator trait for dystocia and is included as a correlated trait in the genetic evaluation, and thus not included in the model for dystocia itself. Stillbirths, early calvings, abortion and twin births are recorded, but are excluded in the further genetic evaluation. The phenotypes for dystocia are divided into calvings by primiparous and multiparous cows, each divided into direct and maternal effects. The breeding values that are presented are the direct and maternal effects for calvings by primiparous cows. The different variances in the old and the new system is in today's genetic evaluation adjusted for by a phenotypic heterogeneous variance adjustment.

The breeding values in the genetic evaluation in Sweden have a mean calculated from animals in the base group. Animals in the base group are animals born between 5 to 9 years ago and have a mean of 100 and a standard deviation of 10. This means that almost all animals in the breed will have a breeding value within ± 3 standard deviations which in turn means a breeding value between 70 to 130. A lower breeding value means, in the case of dystocia, that the animal is expected to give more difficult calvings while a higher value means easier calvings (Växa Sverige 2017b).

2.2 Information collection and processing

The data, which includes all Charolais and Simmental cattle born in Sweden from 1950 until November 2018, used in this report was retrieved from Växa Sverige's database. Växa Sverige is responsible for collection of information from the cattle farmers and also for the estimation and validation of breeding values. The information used in this report was collected for two breeds, Charolais and Simmental. This report will only focus on the calving traits. In the data there were 196,100 Charolais and 74,007 Simmental cattle in total. In the old system there were 169,316 Charolais and 61,425 Simmental cattle that were born before May 2012.

In the new system there were 26,807 Charolais and 12,588 Simmental calvings May 2012. The dystocia grades from animals recorded in the old system with three grades had prior to this study been transformed by Växa Sverige to fit the 4 graded scale in the new system. How the transformation from the 3-graded scale to the 4-graded was made is shown in Table 1. Besides the scores presented in Table 1, the score 8 was given for abortion and score 9 for early calving, but these are not used in the genetic evaluation. The farmers can also report the calving as missing information (score 15).

Table 1. *Transformation of the codes from the old 3-graded scale to the new 4-graded scale.*

Old code	Old description	New code	New description
1 & 2	Easy & normal	11	Easy without help
3	Normal, malpositioned	12	Easy with help
4	Difficult	13	Difficult without help
5	Difficult, malpositioned	14	Difficult with veterinarian help

Besides the data, also three SAS codes and one DMU code were provided by Växa Sverige. The two first SAS codes are processing the phenotypic data that are collected from the farmers. The data are prepared so that DMU can read it, which is the next step. DMU5 software (Madsen & Jensen 2013) is used to estimate breeding values. Those breeding values are expressed and rescaled as relative breeding values in the third SAS code that was provided by Växa Sverige.

The SAS software (SAS Inc. 2015) was used to examine the data and get descriptive statistics. To modify the data to examine the effects on breeding value estimation from using new normal scores and new genetic parameters for calving traits, the SAS codes provided by Växa Sverige were changed. The new and original breeding values were compared to be able to see if there were any difference when changing scores and parameters.

The different sets of normal scores that were used in this study are presented in Table 2. The ‘old scores’ that are used in today’s breeding evaluation are presented together with new sets of normal scores tested in this study. When the old scores were used, an adjustment for heterogeneous variance was also used as in the current genetic evaluation. A first set of normal scores was calculated based on the frequencies in the old and new system. The normal scores were (linearly) transformed such that the dystocia class 1 and dystocia class 2 in the old system would get the values 1 and 2, respectively, following the approach in Malm et al. (2008). The same scores were applied for Charolais and Simmental, as the frequency distribution of the recorded dystocia classes was rather similar for both breeds. Another set of normal scores was calculated taking into account that there are different frequencies of dystocia for calvings by primiparous and multiparous cows. The 'new normal scores' were calculated with the different variances in mind, which means that the adjustment for heterogeneous variance could be omitted.

Table 2. *The different normal scores that were used and investigated. The 'Old' are the original scores used in the current genetic evaluation, 'New' are the new normal scores where no difference was made between parities, and 'New multiparous' and 'New primiparous are normal scores with the different frequencies for calving difficulty in primiparous and multiparous cows taken in account.*

Recording system	Recorded class	Old scores	New scores	New primiparous	New multiparous
Until 2012	1	1	1	1	1
	2	2	2	2	2
	3	3	2.88	2.72	2.75
From 2012	11	1	1.14	1.14	1.13
	12	1.75	2.28	2.23	2.35
	13	2.75	2.62	2.67	2.65
	14	3.5	2.98	3.13	2.97

In today's genetic evaluation, the correlations with the direct as well as the maternal breeding value for dystocia in multiparous cows have been set to zero. This was done to reduce the influence of outlier breeding values for dystocia in multiparous cows on breeding values for other traits. In this study, the correlations were added again when different normal scores were used for calvings by primiparous and multiparous cows. The correlations between the traits can be found in Table 3 and Table 4.

Table 3. *Correlation matrix for genetic random effects as used in the current genetic evaluation. BWD stands for Birth weight direct effect, BWM stands for Birth weight maternal effect, DD stands for Dystocia direct effect, DM stands for Dystocia maternal effect. The following P stands for primiparous and M stands for multiparous.*

	BWD P	BWM P	BWD M	BWM M	DD P	DM P	DD M	DM M
BWD P	1							
BWM P	-0.1336	1						
BWD M	0.7143	0	1					
BWM M	0	0.9	-0.0802	1				
DD P	0.6057	0	0.6057	0	1			
DM P	0	0.1768	0	0.1768	-0.1083	1		
DD M	0	0	0	0	0	0	1	
DM M	0	0	0	0	0	0	0	1

Table 4. *Correlation matrix for genetic random effects after adding correlations as they used to be included in the genetic evaluation. BWD stands for Birthweight direct effect, BWM stands for Birthweight maternal effect, DD stands for Dystocia direct effect, DM stands for Dystocia maternal effect. The following P stands for primiparous and M stands for multiparous.*

	BWD P	BWM P	BWD M	BWM M	DD P	DM P	DD M	DM M
BWD P	1							
BWM P	-0.1336	1						
BWD M	0.7134	0	1					
BWM M	0	0.9	-0.0802	1				
DD P	0.6057	0	0.6057	0	1			
DM P	0	0.1768	0	0.1768	-0.1083	1		
DD M	0.1964	0	0	0	0.2501	0	1	
DM M	0	0.2236	0	0.2236	0	0.9487	0	1

The four different configurations for genetic evaluations (GE) that were studied are shown in Table 5. The scores and correlations used in today's routine genetic evaluation were used in evaluation GE0 in this study, and this configuration serves as base for comparison. Configurations GE1 and GE2 differ from GE0 only in the scores that were used. Finally, in configuration GE3, the same normal scores as in GE2 were used, but also some correlations that are put to zero in GE0-GE2 were replaced by the correlations previously used in the routine genetic evaluation.

Table 5. *Different configuration of genetic evaluations (GE0, GE1, GE2 and GE3) that were used with different scores and correlations*

	Scores	Correlations
GE0	As 'Old scores' in *Table*	As shown in In today's genetic evaluation, the correlations with the direct as well as the maternal breeding value for dystocia in multiparous cows have been set to zero. This was done to reduce the influence of outlier breeding values for dystocia in multiparous cows on breeding values for other traits. In this study, the correlations were added again when different normal scores were used for calvings by primiparous and multiparous cows. The correlations between the traits can be found in Table 3 and Table 4. Table

	Scores	Correlations
GE1	As ‘New scores’ in *Table*	As shown in In today’s genetic evaluation, the correlations with the direct as well as the maternal breeding value for dystocia in multiparous cows have been set to zero. This was done to reduce the influence of outlier breeding values for dystocia in multiparous cows on breeding values for other traits. In this study, the correlations were added again when different normal scores were used for calvings by primiparous and multiparous cows. The correlations between the traits can be found in Table 3 and Table 4. Table

	Scores	Correlations
GE2	As 'New multiparous' and 'New primiparous' in *Table*	As shown in In today's genetic evaluation, the correlations with the direct as well as the maternal breeding value for dystocia in multiparous cows have been set to zero. This was done to reduce the influence of outlier breeding values for dystocia in multiparous cows on breeding values for other traits. In this study, the correlations were added again when different normal scores were used for calvings by primiparous and multiparous cows. The correlations between the traits can be found in Table 3 and Table 4. Table
GE3	As 'New multiparous' and 'New primiparous' in *Table*	As shown in *Table*

2.3 Data comparison

The original and new data sets were divided in subsets with different animal categories or different birth years in order to compare them. Comparisons were made by investigating the residual plots, using residuals estimated with the option RESIDUAL in DMU, for the four different genetic evaluations that were done. Also, residuals were plotted against expected phenotypes estimated using the option RESIDUAL in DMU to examine if these seemed uncorrelated. QQ-plots (quantile-quantile probability plots) were created for the different breeding values obtained from DMU to compare the shapes of the distributions. Those were compared for different animal categories and birth years, as well as for different normal scores and correlations (GE0-GE3). The trends for means, quartiles and 5th and 95th percentiles were compared over the years.

3 Results

3.1 Statistics and dystocia score

The distribution of dystocia categories in the old and new system, respectively, is presented in Table . There was a more uneven distribution of the dystocia scores with the new system than with the old system in both Simmental and Charolais cattle. More calvings were reported as 11 in the new system, which in turn also means that there were less calvings reported as dystocia score 12, 13 and 14 (Table 6). There was a slightly higher frequency of early calvings in the new system compared to in the old system, 0.3 percentage points increase for Charolais and 0.2 percentage points increase for Simmental. There was also a somewhat higher frequency in the category 'other' in both breeds in the new system compared to the old system, 0.8 percentage points higher for Charolais and 0.3 percentage points higher for Simmental. This category contains the scores that are not included in the breeding evaluation, which means that there is a slightly higher frequency of misreporting in the new system than in the old system.

Table 6. *Distribution of different grades recorded for dystocia in the old (until 2012) and the new (after 2012) system. Score 8 is abortion, 9 is early calving, 11 is easy without help, 12 is easy with help, 13 is difficult without help and 14 is difficult with veterinarian help. Other scores that are not the above mentioned are put as other[1]. Animals with no reported phenotype on dystocia are not included in the table.*

	8	9	11	12	13	14	Other	Total
Charolais old	34 (0.0%)	3 (0.0%)	133,131 (86.7%)	16,035 (10.4%)	2,259 (1.5%)	1,177 (0.8%)	906 (0.6%)	153,545
Charolais new	0 (0.0%)	68 (0.3%)	24,768 (92.9%)	1,091 (4,1%)	264 (1.0%)	85 (0.3%)	386 (1.4%)	26,662
Simmental old	12 (0.0%)	2 (0.0%)	46,106 (84.4%)	6,728 (12.3%)	832 (1.5%)	413 (0.8%)	556 (1.0%)	54,649
Simmental new	0 (0.0%)	26 (0.2%)	11,298 (91.7%)	650 (5.3%)	136 (1.1%)	55 (0.4%)	155 (1.3%)	12,320

[1]*In the column marked as 'other' there are reported phenotypes that are not reasonable, for example 24 which is not an alternative when reporting the dystocia score. No observation had been reported as missing information for Simmental or Charolais cattle in the data used in this study.*

3.2 Breeding values

The minimum estimated breeding values from GE0 and GE3 are shown over the years in Table 7. The lowest breeding values for direct effect for dystocia in calvings by multiparous cows in GE0 for the years after 2012 were extremely low, which indicates some problems that have occurred after the change to the new reporting system. When using GE3, the corresponding breeding values were still low, but they were not negative as they are when using GE0.

There were more extreme breeding values for dystocia in the new system compared to in the old system. This can be seen especially for the direct breeding value for multiparous cows using GE0 (see *Figure 1*). For example, the lowest direct breeding value for dystocia in multiparous cows born in 2007 was 32.7, while for those born in 2016 it was -41.9 (Table 7).

Table 1. *A table over the minimum breeding values estimated for dystocia for each different birth years for all Simmental. MP stands for maternal primiparous, MM stands for maternal multiparous, DP stands for direct primiparous and DM stands for direct multiparous; all of them refers to the breeding value for dystocia. The following GE0 and GE3 stands for the different genetic evaluations that are investigated in this report (*

Table *). N is the number of animals born that year.*

Year	N	MP GE0	MP GE3	MM GE0	MM GE3	DP GE0	DP GE3	DM GE0	DM GE3
1990	1093	47.0	42.4	64.1	47.5	65.8	61.6	33.3	44.4
1991	1349	46.7	40.2	60.4	42.4	64.7	63.2	45.3	50.1
1992	1556	35.2	34.0	54.4	35.8	54.3	46.0	27.5	37.9
1993	1753	48.1	41.2	65.6	43.9	66.4	59.4	25.9	35.3
1994	1852	41.1	44.1	71.5	47.7	65.4	64.8	23.4	32.8
1995	1945	47.4	49.0	71.8	51.7	61.6	61.6	19.1	28.9
1996	2195	57.8	42.4	64.0	45.8	63.1	57.8	29.8	31.2
1997	2295	55.4	47.3	72.2	51.0	66.2	61.2	42.7	44.3
1998	2407	57.7	57.3	73.5	60.8	62.9	58.4	42.1	44.8
1999	2588	54.2	47.7	72.2	51.9	49.3	49.6	29.2	38.3
2000	2666	60.2	57.7	72.1	60.8	66.1	65.0	25.6	36.2
2001	2746	48.4	46.2	72.1	51.2	57.2	50.8	34.2	43.6
2002	2638	61.2	51.9	74.3	56.7	61.9	63.4	30.7	40.9
2003	2763	62.1	62.2	70.8	66.4	57.2	56.4	33.5	42.5
2004	2916	64.5	59.7	70.4	63.4	54.2	52.0	26.8	35.4
2005	3009	66.8	64.9	76.4	67.9	53.7	55.4	46.3	54.8
2006	2902	64.2	58.3	69.7	58.8	61.2	58.3	37.1	47.2
2007	2980	68.8	68.2	70.2	70.8	57.9	52.3	32.7	39.9
2008	2930	56.7	61.5	67.7	62.2	63.3	57.9	31.4	40.6
2009	2992	66.2	63.2	67.9	63.4	65.8	56.9	43.0	48.4
2010	2911	55.8	59.5	41.2	61.7	62.3	56.7	-14.5	24.4
2011	2719	44.0	56.1	68.9	58.6	57.8	54.0	40.1	49.2
2012	2378	46.0	53.5	56.6	55.8	58.9	54.0	15.5	49.2
2013	2169	43.1	54.8	68.9	58.6	51.8	54.0	-39.7	49.2
2014	2129	48.0	62.5	73.3	63.2	57.7	58.5	-42.6	32.6
2015	1968	43.7	56.2	59.1	54.8	55.6	46.7	-48.0	34.8
2016	1926	49.9	65.4	69.1	60.8	60.9	56.4	-41.9	33.8
2017	2042	75.0	73.9	69.1	70.8	41.7	35.7	-56.1	32.3
2018	2003	73.8	75.5	69.2	66.3	63.1	56.6	-65.4	31.3

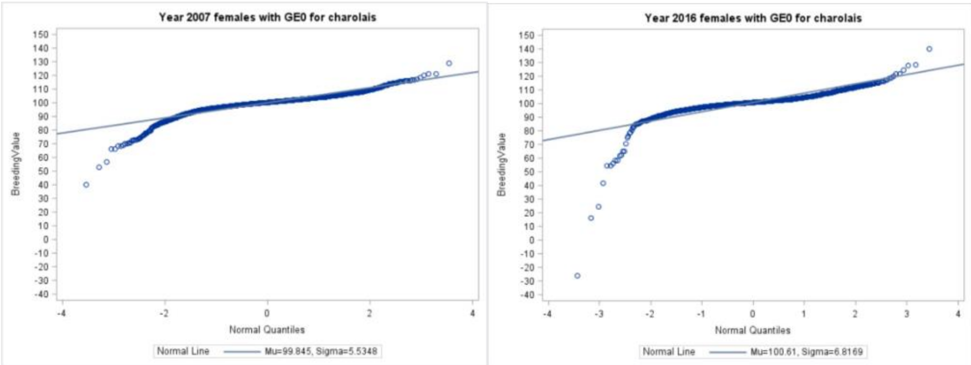

Figure 1. QQ-plot of direct breeding values of dystocia in calvings by multiparous Charolais cows using GE0. To the left presenting the breeding values from animals born in 2007 and to the right the breeding values from animals born in 2016. High breeding values are favourable (less dystocia).

As seen in *Figure 2* the curves in QQ-plots of breeding values had similar shape when using the GE0 and GE2. The lowest breeding values, however, were not as extreme when using GE2 compared to when using GE0: -26,2 compared with 49,8. Only a very small difference was seen when using GE3 compared to GE2, however. Adding more genetic correlations in the analysis using GE3 thus only gave a small difference. Similarly, this also made a small difference for the direct breeding values for dystocia for primiparous cows.

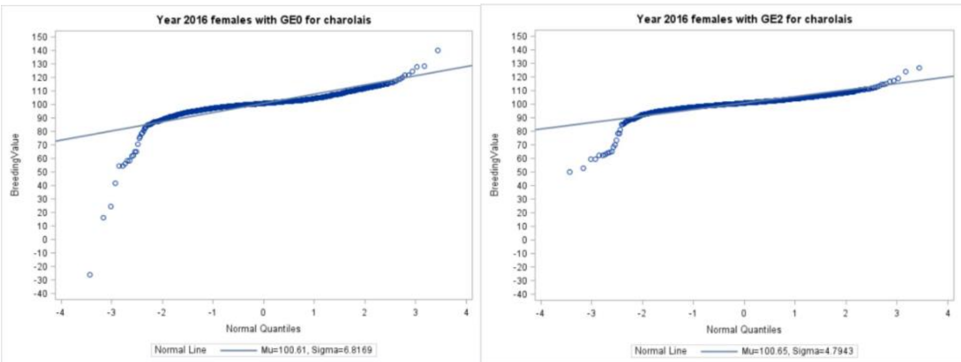

Figure 2. QQ-plots for direct breeding values of dystocia in calvings by multiparous Charolais cows. To the left is the QQ-plot using GE0 and to the right using the GE2. High breeding values are favourable (less dystocia).

The QQ-plots for direct breeding values for dystocia in calvings by multiparous cows using GE3, for the animal categories heifers that had not calved, cows that had calved one time, and cows that calved 5 times is shown in *Figure 3*. For all animal categories, the lowest breeding values were lower than the distribution reference line. The distribution reference line is a line that is created by SAS software that shows the expected relation between observed and theoretical quantiles if the data were normally distributed, assuming the sample mean and standard deviation. For cows that had calved 5 times the plot showed a quite smooth line, while for both heifers and cows that had calved 1 time there was more of a bump where it turns downwards.

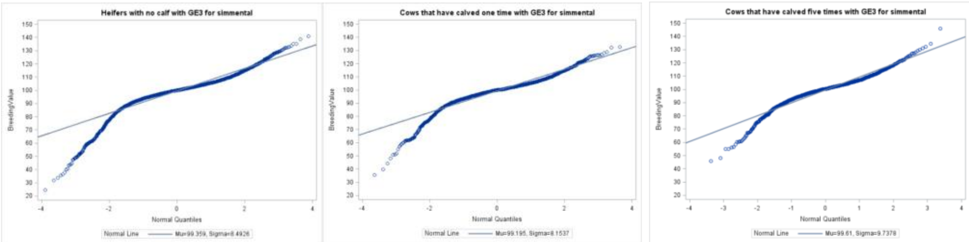

Figure 3. QQ-plots for direct breeding values for dystocia in calvings by multiparous Simmental cows using GE3. To the left is the graph for breeding values for heifers, in the middle for cows that have calved 1 time and to the right is for cows that have calved 5 times. High breeding values are favourable (less dystocia).

The correlation between the corresponding breeding values estimated using different genetic evaluations were quite high, which can be seen in Table 8. The correlations between maternal breeding value for dystocia in calvings by primiparous cows and also the direct breeding values for both calvings by primi- and multiparous cows was above 0.95. The correlation between the maternal breeding value for dystocia in calvings by multiparous cows from using GE0 and GE3 was however lower, 0.59. However, when comparing GE0 and GE2 for the maternal breeding value for dystocia in calvings by multiparous cows, the correlation was 0.98 (not shown in figure).

Table 2. *The correlations between the corresponding breeding values for dystocia estimated in the GE0 and GE3 evaluations, for calvings by primiparous and multiparous cows, calculated for all females of Simmental.*

	Maternal primiparous	Maternal multiparous	Direct primiparous	Direct Multiparous
Correlation	0.957	0.586	0.985	0.963

The mean of breeding values for dystocia (maternal and direct for calvings by primi- and multiparous cows) compared over the years is shown in *Figure 4*. This figure shows that the genetic trend for the maternal effects for dystocia for both calvings by primi- and multiparous cows has increased over the years. The genetic trend for the direct effects for dystocia for calvings by multiparous cows seem to have a slight increase over the years, while for calvings by primiparous cows the genetic trend seem to be quite unchanged over the years.

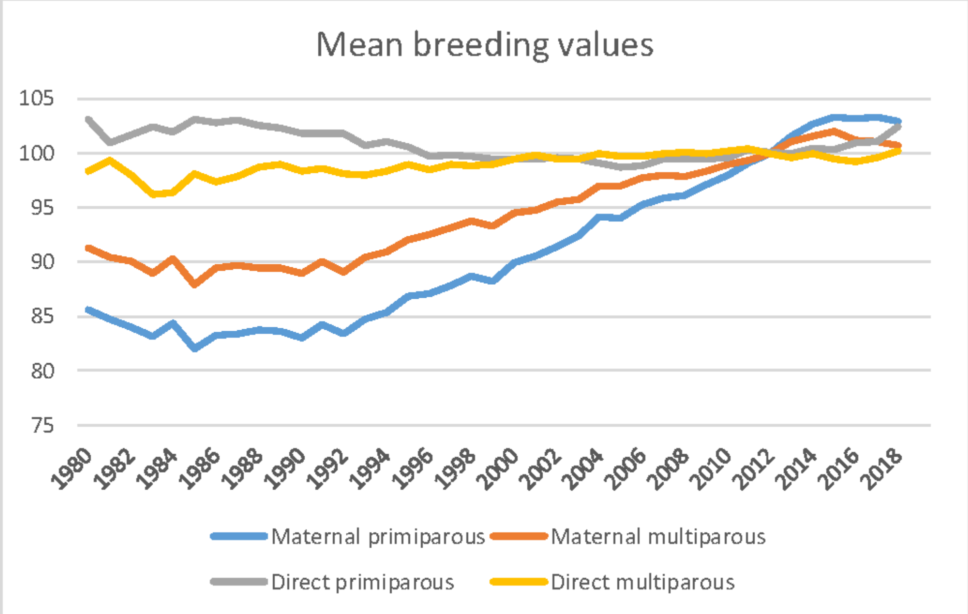

Figure 4. Mean of the breeding values for dystocia for the years 1980-2018 using GE3 in Simmental. Higher breeding values are favourable (less dystocia).

3.3 Residuals

When examining the residuals for dystocia for calving by primiparous cows with GE0, the highest value in the QQ-plot for residuals was about 1 unit above the distribution reference line for Simmental (*Figure 5*). In the corresponding QQ plot for residuals from the GE3 for Simmental the highest value was about 0.4 units above the distribution reference line (*Figure 5*). The difference was even bigger in the QQ plot for residuals for dystocia in calvings by multiparous cows. For Simmental the highest value was then about 2.4 units above the distribution reference line with GE0 and about 0.75 with GE3 (*Figure 6*).

The residuals for birth weight were close to the distribution reference line in the QQ-plot and thereby closer to be normally distributed. It is illustrated for Simmental calvings by primiparous cows with GE0 in *Figure 7*. As seen in the same figure, when changing to GE3 there was no or very small difference of the QQ-plot for residuals compared to GE0. There are some extreme values at the top and the low range in the residual plots. These values differ somewhat from the expected distribution reference line. When plotting the residuals for birth weight against the expected birth weight, the points were distributed around zero. However, there seemed to be a tendency for the residuals to increase as the expected birth weight increases.

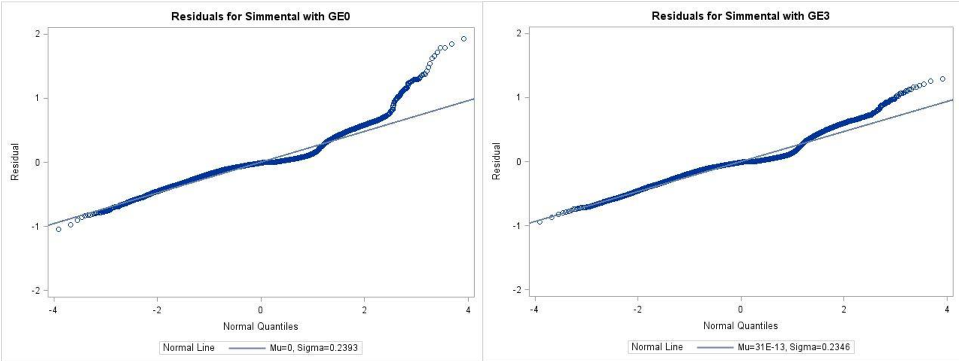

Figure 5. QQ-plot for the residuals from genetic evaluation of dystocia in calvings by primiparous Simmental cows. The plot to the left is from using GE0 and the right is from using GE3.

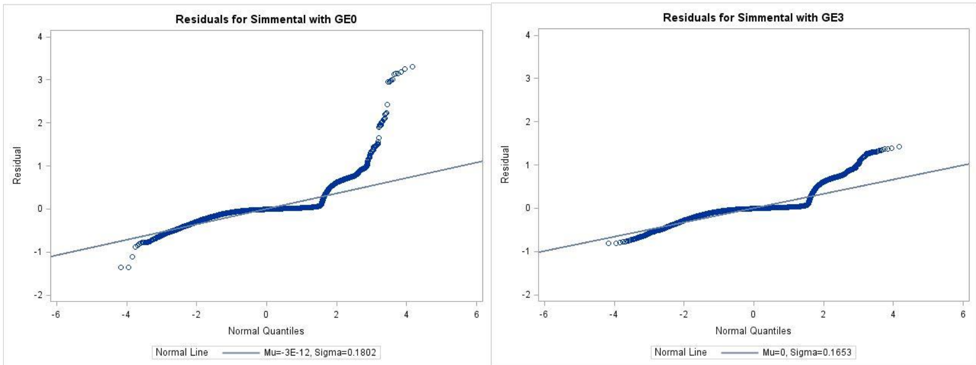

Figure 6. QQ-plot for the residuals from genetic evaluation of dystocia in calvings by multiparous Simmental cows. The plot to the left is from using GE0 and the right is from using GE3.

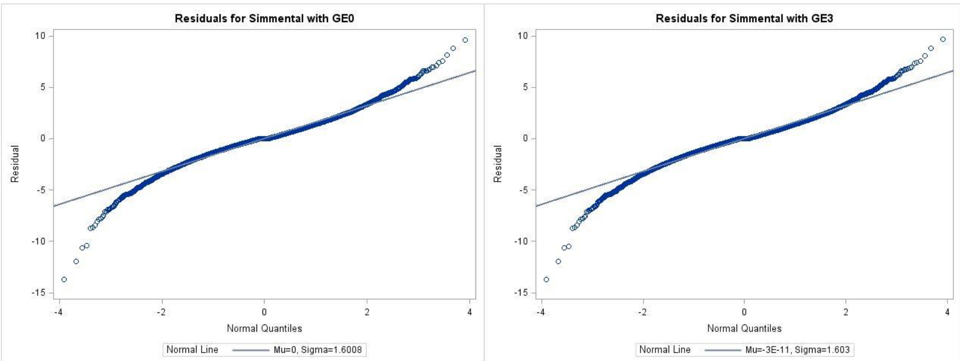

Figure 7. QQ-plot for the residuals from genetic evaluation of birth weight when the mothers were primiparous Simmental cows. The plot to the left is from using GE0 and the right is from using GE3.

Plots where the residuals are plotted against expected phenotypes (residual plot) for dystocia in calvings by primiparous and multiparous cows are shown in *Figure 8* and *Figure 9*. The 7 different classes (3 from the old system and 4 from the new system) are easy to distinguish in the 7 distinct lines in the plots. Neither of the sets of residuals from GE0 or GE3 of calvings by primi- and multiparous cows seems to behave as expected: the residuals for every class are not evenly distributed around 0. This is especially distinct when looking at the residual for calvings in multiparous cows. It seems that GE3 performed better than GE0, however.

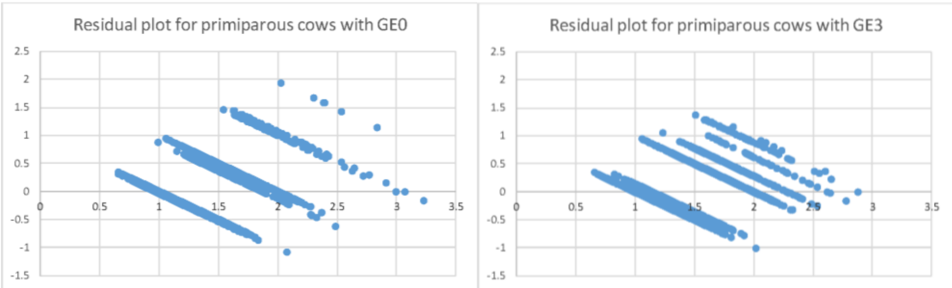

Figure 8. Residual plot from the genetic evaluation of dystocia in calvings by primiparous cows. To the left is the residual plot using the GE0 and to the right is the residual plot using GE3. On the x-axis is the expected phenotype of the breeding value, on the y-axis is the residual of the breeding value. Low phenotypic values are favourable.

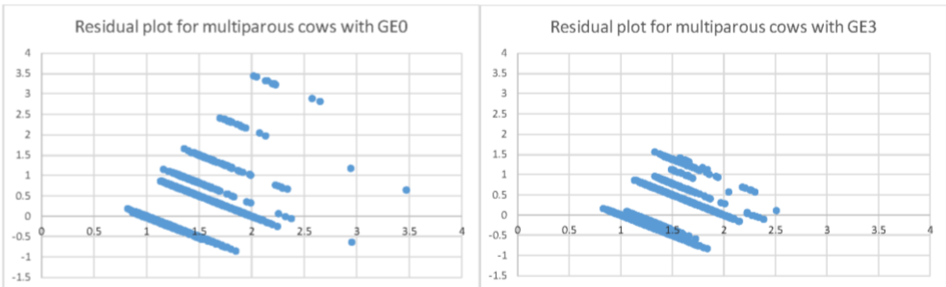

Figure 9. Residual plot from the genetic evaluation of dystocia in calvings by multiparous cows. To the left is the residual plot using the GE0 and to the right is the residual plot using GE3. On the x-axis is the expected phenotype of the breeding value, on the y-axis is the residual of the breeding value. Low phenotypic values are favourable.

4 Discussion

4.1 Statistics and dystocia score

As seen in Table 6, a higher percentage of the calvings were seem to be reported as code 11 (easy without help) for dystocia after the change in 2012 than before. This changed the distribution of the phenotypes quite markedly, which in turn caused a problem in the genetic evaluation.

There seem to be more calvings that have been reported wrongly in the new system compared to the old system, due to the higher frequency of calvings in the category ‘other’. One explanation for this can be that the farmers have not yet learned the new system fully, which in turn makes them unsure what to report and thereby they report the calving wrongly. Another explanation could be that the new system is more difficult to handle. In the case of the reported dystocia e.g. as 24, there is a good guess that it should have been reported as 14 but that there was a typographical error.

The fact that there was no reported abortion in the new system can be due to the fact that there are fewer animals in the new system. There were only a few abortions that have been reported in the old system, so few that the percentage did not even reach 0.1%. The increase in early calving can be another reason why the abortion has decreased. Maybe some abortion has been wrongly reported as early calving. Another reason for the increase is that the farmers may be more aware of the different scores since the new system was introduced.

4.2 Breeding values

There was a big difference between the level of the extremely low values in the new system compared to the old. The new system had more extreme breeding values than the old system using GE0, even breeding values that were negative.

The negative values were for breeding values of direct effect of dystocia in calvings by multiparous cows appeared mainly after 2012, with the exception of 2010 (Table 7). This outlier was probably a cow born in 2010 but that calved after May 2012 with a dystocia grade of 14, which gave her a really bad breeding value. When changing to GE3 the minimum breeding values were not as low as they were in GE0. This indicates that the cows that had a dystocia grade of 14 did not receive as extremely low breeding value as they did in GE0. This is probably because the assigned score that the cows received when reporting dystocia grade 14 for calvings in multiparous cows in GE0 after the correction for heterogeneous variance was 5.426, while the corresponding normal score using GE3 is only 2.97. It seems like the heterogeneous variance adjustment has put an extra big penalty on the cows with dystocia grade 14 due to the big difference in frequencies between the two systems. When using normal scores, as in GE3, one can avoid extremely big penalties.

The resulting breeding values from GE1 and GE2 seems to be more normally distributed than those from GE0, because the lowest values in the QQ-plot for the breeding values for dystocia were closer to the distribution reference line in GE1 and GE2 than in GE0. They are still not perfectly matched with the distribution reference line, which indicates that the distribution is not completely normal. When comparing the distribution of breeding values from GE2 with GE3 there was only a small difference between the QQ-plots. This indicates that the added correlations only made a small difference for the breeding values. This result gives a good reason to include these correlations again when normal scores are used, to take advantage of the correlated information from dystocia in calvings by multiparous cows in the genetic evaluation.

The heifers that had not calved had lower minimum breeding value than cows that had calved one time, for the breeding value of dystocia in calvings by multiparous cows. The difference is bigger when comparing heifers that had not calved with cows that had calved 5 times. This may be due to the fact that calves that have experienced a severe dystocia are not animals selected for breeding. Those animals are probably rather slaughtered, leaving their place in the breeding herd for one that have had an easy parturition. The primiparous cows that give birth with severe dystocia probably have a higher risk of getting culled, while the good cows will continue to give birth to more calves. This can explain the fact that multiparous cows with 5 calves did not have as low minimum breeding values as heifers or primiparous cows. Also, if a multiparous cow gets a calf with severe dystocia, that calving is evened out with the other calvings from that cow, which makes the penalty in breeding values for that severe dystocia less strong than if it had been on a primiparous cow.

The correlations between breeding values from GE0 and GE3 were strong for the maternal breeding value for dystocia in calvings by primiparous cows as well as for the direct breeding values for dystocia in calvings by both primi- and multiparous cows. This indicates that there was an effect of changing the genetic evaluation, which is what is desirable in this study. The change however was not so big that it makes a huge difference in the genetic evaluation. However, the correlation between breeding values from GE0 and GE3 for the maternal effect for dystocia in calvings by multiparous cows was lower, while it between GE0 and GE2 was high. This indicates that the effect of adding genetic correlation affect some traits more than others. The genetic correlation between the maternal effect for dystocia in calvings by primiparous and the corresponding trait of calvings by multiparous that were added was high (0.95). This probably affected the breeding values for the maternal effect of dystocia in calvings by multiparous cows so the correlation between the corresponding breeding value in GE0 was low.

The genetic trend for dystocia over the years has been favourable for the maternal effects. This indicates that the genetic evaluation works rather well and the beef breeding in Sweden has improved the genetics of the animals. The genetic trend for the maternal effects was previously increasing (which is favourable), while in the last years, it has increased that much. The direct effect of dystocia in calvings by primiparous cows have the last years increased more than before. This may be due to the different economic weightings in the indices, which was introduced in 2009. The direct effect has a higher economic weighting than the maternal effect in the current index, which drives the breeding towards genetic improvement for the direct effects more than the maternal effects.

4.3 Residuals

The QQ-plots for the residuals for dystocia in both primi- and multiparous cows showed deviations from normal distribution in the genetic evaluation that were made in this study. However, when using GE1, GE2 and GE3 the line in the QQ-plot was closer to the distribution reference line than when using GE0. This indicates that the residuals from GE1, GE2 and GE3 were more normally distributed than GE0. GE2 seems to give more normally distributed residuals than GE1, and GE3 gave very similar results to GE2. The residuals show the difference between the predicted phenotype and the recorded phenotype. Less difference from distribution reference line indicates that the data follows the assumptions of the model more closely.

All curves in the QQ-plots for residuals from genetic evaluation of dystocia in both Simmental and Charolais had kind of the same shape, with a few bumps on the line. One explanation is that the report system is not continuous, it is split into different classes. The different classes have similar phenotypic value but have within group variation in predicted phenotype. The next class is then started at the next bump.

The QQ-plot for residuals from the genetic evaluation of birth weight did not change noticeably much when GE3 was compared to GE0. The scores were just updated for the trait dystocia, and the residuals for birth weight were not affected much by that. However, there seems to be some systematic effect that is not corrected for in the genetic evaluation, due to the increased residuals when the expected birth weight increase. Also, the highest and lowest values were not perfectly aligned to the distribution reference line, which indicates that some systematic effect are missing in the model.

The different classes were easy to detect in the residual plots for dystocia for both primi- and multiparous cows. The residual plots did not seem to follow the assumptions made by the model fully, in that case the residuals for each class would have been centered around zero. In GE3 the residuals in each class were closer to zero which indicates that they were model and data were better aligned. The residual plot for birth weight (not shown) was more centered around zero. There seemed to be a positive correlation between the expected phenotype for birth weight and the residuals from the genetic evaluation, however, which indicated that there is some systematic effect is not accounted for in the model.

4.4 Suggestions for improvement

The four grades in today's reporting system for dystocia is easy without help, easy with veterinarian help, difficult without help and difficult with veterinarian help. This means that the farmers can only choose between easy and difficult when reporting, which may influence the grade that is reported. It becomes a subjective choice if it really is a difficult calving. In the previous system there was a grade that was 'normal calving with help from one person', which made it a grade that is somewhere in between easy and difficult. This means that if a calving went quite good there was a choice to report it as normal. The frequency of the grades was more even between the classes in the old system, and this may be one reason why.

In today's system there is no possible choice to report the calf as malpositioned. In the case of a malposition the farmer should try to imagine how the calving had gone if the calf had been in the right position. This have led to some confusion for the farmers who don't know how to report the malposition, and also wrong reporting of the calvings that are malpositioned. Even if the calving is correctly reported, there is a subjective element that the farmer should imagine how the calving would have proceeded. To add another choice in the reporting; that the calf was malpositioned, could decrease the risk of wrongly reported dystocia’s.

5 Conclusion

Today's beef breeding for calving performance seems to work well overall, in that the genetic trend for dystocia is favourable with increasing breeding values over the last years. However, the current genetic evaluation for dystocia does not seem to be optimal, as cows with severe dystocia get extremely low breeding values. The consequence might be that a genetically superior animal is leaving their place in the breeding herd due to the low breeding values for calving performance to an animal with lower breeding values in other traits with a higher overall breeding value. When removing the heterogeneous variance adjustment and using transformed normal scores, the extremely low breeding values became less extreme. Also, the breeding values and residuals then seem to be more normally distributed than in the current evaluation.

Acknowledgements

I would like to thank my supervisors Susanne Eriksson and Freddy Fikse for great help and support throughout my work.

I would also like to thank Emma Carlén at Växa Sverige for answering my questions about the beef breeding scheme.

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