Management Guides

E-14
Direct Calving Ease
Maternal Calving Process

Introduction

Of all AI sires data is collected about the ease of the birth of their offspring. The purpose of the calving ease registration is to prevent particularly calving problems with heifers by a targeted use of sires whose offspring is born easier. These sires are suitable for use on maiden heifers. In addition, many beef sires are also tested on Calving Ease of their offspring. This is meant to create the possibility to select suitable beef sires for commercial breeding to dairy cattle. Since 1989 breeding values for sires have been calculated by use of the collected birth data: the breeding value direct calving ease. Since 1997 sires have also received a breeding value for the maternal calving process. Research shows a negative correlation between the ease with which a calf is born and the ease with which that same calf gives birth to her offspring later. The breeding value Maternal Calving Process (MCP) shows the calving ease for the daughters of the sires.
Starting in November 2004 the breeding value estimation is a joint evaluation based on data collected in the Netherlands and in Flanders.
In this part the breeding values estimation for Calving Ease and MCP are further explained.

Data collection

CRV

CRV offers bull controllers a service to collect birth process data of a bull's offspring. Until the end of 2006, the possibility existed to collect information through the so-called survey system. However, since the beginning of 2007 birth process data are stored when a farmer reports the birth of a calf through herd management systems.

Survey system
Shortly before the offspring of the bull was born, the bull controller himself or CRV, on behalf of the bull controller, sent a birth survey to the farmer.
The survey contained questions about calving ease and birth weight. Farmers were asked to complete the survey and return it to the bull controller. The surveys were processed in the CRV-Information System. As mentioned, this was done until the end of 2006.

Calving Ease
Calving ease is scored in six categories:
1 = easy
2 = normal
3 = hard pull
4 = caesarean section
5 = fetotomy
6 = other veterinary aid

When VRV was still conducting surveys in Flanders, there were four classes in which calving ease was divided:
1 = no help
2 = slight assistance

3 = hard pull
4 = caesarean or fetotomy

This data was then processed by VRV. Nowadays this is done by CRV.

Gestation length

The gestation length trait is calculated as the difference in days between the date of insemination and the date of calving.

Birth weight of the calf

Survey System

On the survey, the birth weight trait of calves was divided in 12 classes of 5 kg each. The lowest class was for calves of 22 kg and less, the next class was for 23-27 kg, etc. The highest class was for calves of 73 kg or more. The farmer gave a score to the weight class of the calf that was born. For the breeding value estimation these weight classes were converted into kilograms.

Herd management systems

Since 2007, farmers enter the estimated or weighted weight of the newborn calf in kilograms when registering the birth of the calf.

▪ Data

Observation

For the breeding value estimation, the number of classes is reduced to 4. This is done by adding score 6 to score 3 and score 5 to score 4. The four classes are similar to the classes used by VRV. As a result, the following division is created:

1 = easy
2 = normal
3 = hard pull and other veterinary aid
4 = caesarian and fetotomy

Observations on calving ease, gestation length and birth weight are used. Calving ease observations are transformed to an underlying normal distribution to account for differences in frequencies. The transformation is stratified through data collection, by region (Flanders and the Netherlands), by parity (first versus higher) and by three-year-period. Definition of the different classes for calving ease is slightly different in Flanders and the Netherlands. The transformation helps to avoid undesirable effects of this difference in definition on breeding values as much as possible.

Characteristics of the transformation: for each stratum (combination of data collection x region x parity x three-year-period) the frequencies are calculated. This frequency is transformed to a number from an underlying normal distribution that matches the frequency. Figure 1 shows an example of this transformation.

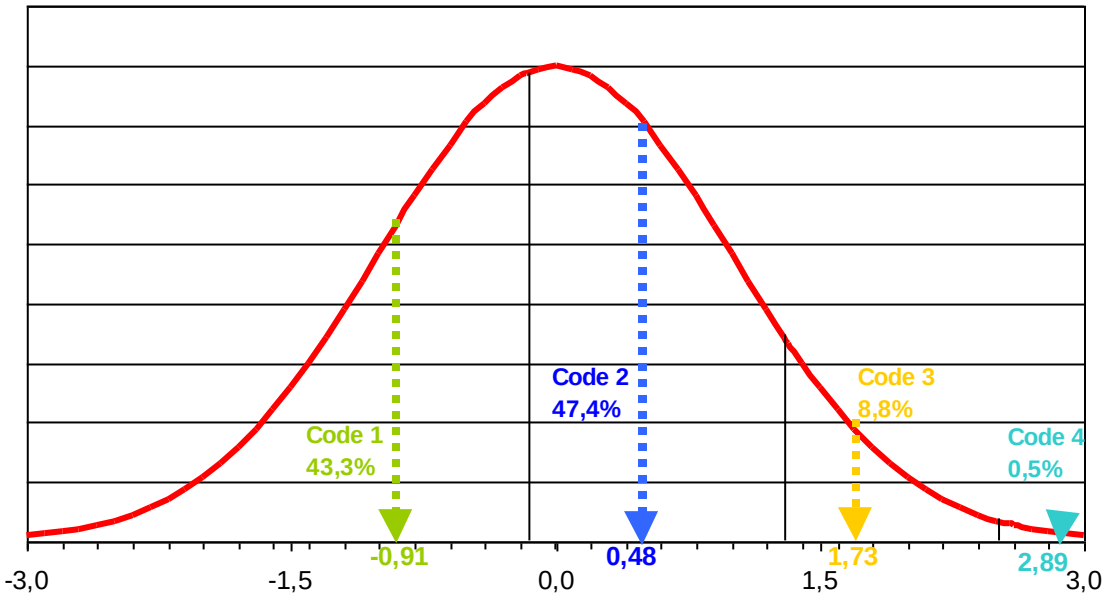

Figure 1. Frequency distribution of calving ease and associated transformation to a normal distribution

In figure 1 class 1 has 43.3% of the observations; class 2 has 47.4% of the observations; class 3 has 8.8% and class 4 has 0.5% of the observations. These percentages are transformed to a normal distribution where class 1 is converted to the number –0.91, class 2 is converted to 0.48, class 3 to 1.73 and class 4 to 2.89. These numbers are the observations that are used in the breeding value estimation instead of the original numbers 1 to 4.

Selection of data for breeding value estimation

The breeding value estimation uses data that meet the following demands:

- the information of a birth recording is complete, i.e. the farm where the calf has been born is known, the sex of the calf is known, the parity number is known, the sire of the calf is known, the calving ease category is known;
- the gestation period is between 260 and 305 days;
- the birth weight of the calf is between 20 and 75 kilograms, or is missing;
- the calf was not born as part of a multiple birth.
- the dam of the calf has to be herd book registered;
- if a farm has more than 10 birth notifications per calendar year, the spread of the scores for calving ease within a calendar year should be at least 0.20;

▪ Statistical model

The calculation of the indexes is done with an animal model including a direct and maternal effect, in accordance with the BLUP technique (Best Linear Unbiased Prediction). The following statistical model is used to estimate breeding values for birth traits of bulls:

For heifers:

$$Y1_{ijklmnopqrtuv} = CG_i + YM_j + AGE_k + SEX_l + Hcow_m + Rcow_n + Hcalf_o + Rcalf_p + Icow_u + Icalf_v + COW_q + CALF_r + E_t$$

For cows:

$$Y2_{ijklmnopqrtuv} = CG_i + YM_j + PAR_k + SEX_l + Hcow_m + Rcow_n + Hcalf_o + Rcalf_p + Icow_u + Icalf_v + COW_q + CALF_r + E_t$$

In which:

$Y1_{ijklmnopqrtuv}$: observation during the birth of calf *r* to heifer *q* in management group *i*, born in year x month *j*, with age *k* and sex *l*, where heifer *q* has heterosis *m* ,recombination *n* and inbreeding *u*, and where calf *r* has heterosis *o*, recombination *p* and inbreeding *v*;

$Y2_{ijklmnopqrtuv}$: observation during the birth of calf *r* to cow *q* in management group *i*, born in year x month *j*, with parity *k* and sex *l* and with permanent environment *s*, where cow *q* has heterosis *m*, recombination *n* and inbreeding *u*, and where calf *r* has heterosis *o*, recombination *p* and inbreeding *v*;

CG_i : herd or management group *i*;

YM_j : year x month of birth *j* of the calf;

AGE_k : age at calving *k* of the calf *p* x 3 year;

PAR_k : parity *k* of cow *p* x 3 year;

SEX_l : sex *l* of calf *r* x 3 year;

$Hcow_m$: heterosis *m* of cow *q*;

$Rcow_n$: recombination *n* of cow *q*;

$Hcalf_o$: heterosis *o* off calf *r*;

$Rcalf_p$: recombination *p* of calf *r*;

Icowu : inbreeding *u* of cow *q*;

Icalfv : inbreeding *v* of calf *r*;

COW_q : additive genetic effect of cow *q* or the maternal effect;

$CALF_r$: additive genetic effect of calf *r* or the direct effect;

$PERM_s$: permanent environment effect *s* of cow *q*;

E_t : residual of Y1 or Y2, which is not explained by the model.

The effects COW_q, $CALF_r$, $PERM_s$ and E_t are random effects. Heterosis, recombination and inbreeding are co-variables and the other effects are included in the model as fixed effects.

Effects in the model

The effects in the model are:

1. Herd or management group;
2. Year x month of birth;
3. Age at calving x 3 years for heifers;
4. Parity x 3 years for cows;
5. Sex of the calf x type of calf x 3 years;
6. Heterosis of the cow;
7. Recombination of the cow;
8. Heterosis of the calf;

9. Recombination of the calf;
10. Inbreeding of the cow;
11. Inbreeding of the calf;
12. Additive genetic effect for the cow or the maternal effect;
13. Additive genetic effect for the calf or the direct effect;
14. Permanent environment effect.

Herd or Management Group
Before 2007, per herd all sent survey cards during a year formed a management group. If the minimum of 10 was not reached within a year, the period was extended till the minimum was reached. The period was extended to a maximum of three years. The observations in this management group were compared with one another. By dividing the observations of a herd in management groups, the possible difference in scoring over time by the farmer was taken care of. Differences could have arisen as a consequence of a change in the personal definition of calving ease and birth weight of the calf by the farmer, a change of the person completing the survey, a change in the kind of cows, or a change of circumstances in the herd. If three years after the return of the first survey the number of 10 had not been reached yet, the group was closed after all.

Month of birth
During the year, calving ease, gestation length and birth weight of the calf differs. For heifers, at the end of summer, less difficult births appear than in the winter. For cows less difficult calvings appear to in the summer than in the winter (see Figure 2). For heifers, the biggest difference is found between the months of March and September. Calvings in March produce 4.3 percent more difficult births than calvings in September. The biggest difference for cows is found between the months of February and July. Calvings in February produce 1.7 percent more difficult births than calvings in July.

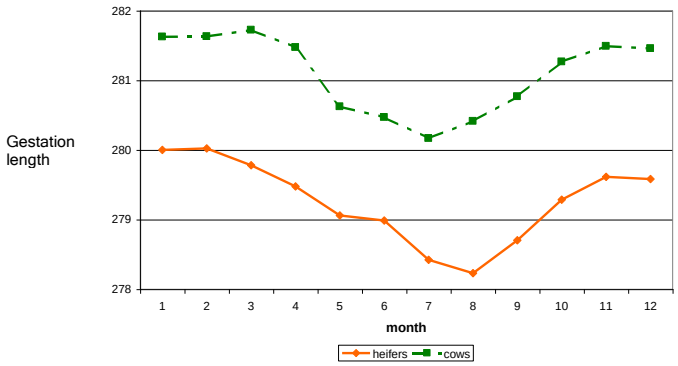

Figure 2. Effect of month on calving ease

Gestation length follows the same pattern as the calving ease trait, with longer gestation length in the winter and spring, and shorter gestation length in the summer for both cows and heifers (see Figure 3). Calves born in the autumn to cows have higher birth weights than calves born in spring (see Figure 4). Calves born to heifers have hardly any difference in birth weight in the different months throughout the year (Figure 4).

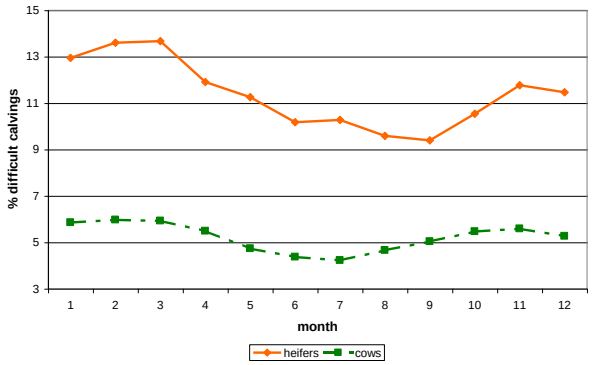

Figure 3. Effect of month on gestation length

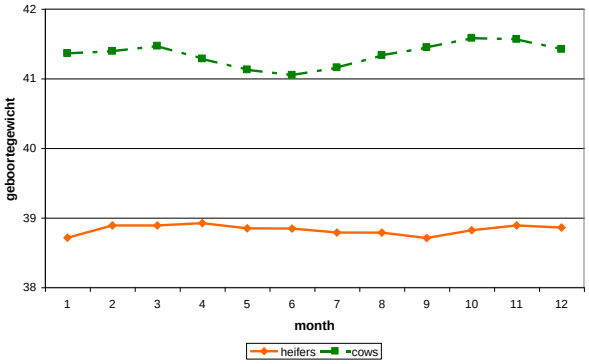

Figure 4. Effect of month on birth weight

The fact that cows have more trouble calving in November is mainly caused by the higher birth weight of the calf. In the spring period, the birth weight drops due to which also the percentage of difficult births goes down. In the January-April period, at the end of the barn season, the percentage of difficult births increases again. This is probably caused by the worse physical condition of the cow, whereas the birth weight remains equal to the period prior to it. During the grazing period the percentage of difficult births drops and the birth weight remains the same. The cows are then in a better physical condition, which eases the birth process. To take account of changes over time, the month effect is included in the model as year x month. Correction for the month in which the calves are born is important for test bulls because most of the inseminations are done within two months. Should this correction not be applied, then the results of a sire could easily be affected by the period in which his calves are born.

Calving age x 3 years

In analysing the birth traits, age at calving is taken into account for heifers. Age has an effect on calving ease, gestation length and birth weight. Heifers that calve young, when they are 20 months old, have less difficult births than heifers who are older when they calve, over the age of 32 months (see Figure 5). Young heifers have 2.6 percent less difficult births than old heifers.

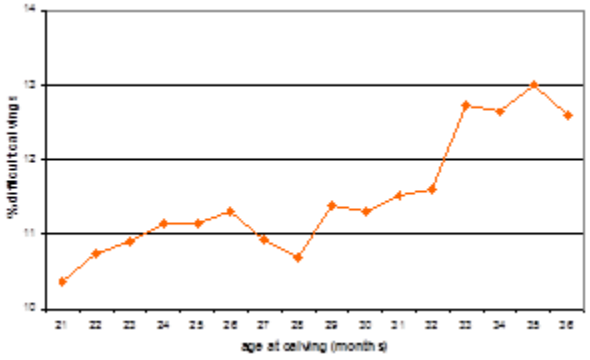

Figure 5. Effect of calving age on calving ease

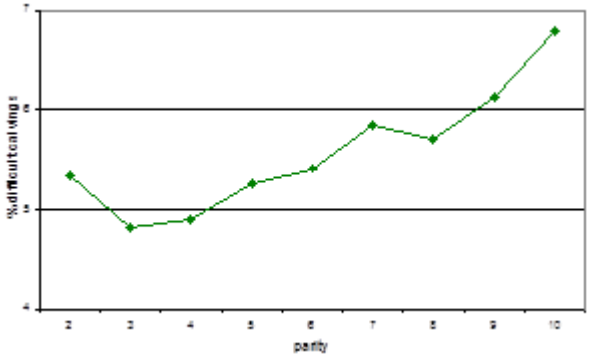

Figure 6. Effect of parity on calving ease

Eighteen age classes are differentiated, with class 1 correcting for calving age of 20 months or younger. Class 2 to 17 corrects for calving age of 21 to 36 months. Class 18 contains all heifers that are 37 months or older at calving. The age classes are divided into 3-year periods. Working back from the earliest calving date in the breeding value estimation, 3-year periods are formed. If the last period is shorter than 2 years, it is combined with the next period. The division into 3-year

periods has been carried out in order to take account of changes in the way in which farmers report births over time.

Parity x 3 years for cows
In analysing the birth traits, parity at calving is taken into account for cows. Parity has an effect on calving ease, gestation length and birth weight (see Figure 6). Third and fourth parity cows have the least difficult births; after that the percentage of difficult births increases again. The biggest difference is between the fourth and tenth parity cows, with a difference of 2.0 percent.
Nine parity classes are distinguished. Class 1 to 8 corrects for parity 2 to 9. Class 9 contains all cows with a parity of 10 or higher. The parity classes are divided into 3-year periods. Working back from the earliest calving date in the breeding value estimation, 3-year periods are formed. If the last period is shorter than 2 years, it is combined with the next period. The division into 3-year periods has been carried out in order to take account of changes in the way in which farmers report births over time.

Sex of the calf x type of calf x 3 years
In analysing the birth traits, the sex of the calf is taken into account. Bull calves considerably have more difficult births and are heavier than heifer calves (see Figure 7). In heifers, 15.6% of bull calves have difficult births, compared with 6.9% difficult births for heifer calves. In cows, 7.3% of bull calves have difficult births, compared with 2.9% difficult births for heifer calves. The type of calf is also taken account for, that means that if the calf was born from an insemination, natural service, born from a MOET embryo, born from an OVU-IVP embryo, or born from an embryo produced by another method of embryo production. Calves born from an OPU-IVP embryo are heavier and have more difficult births.

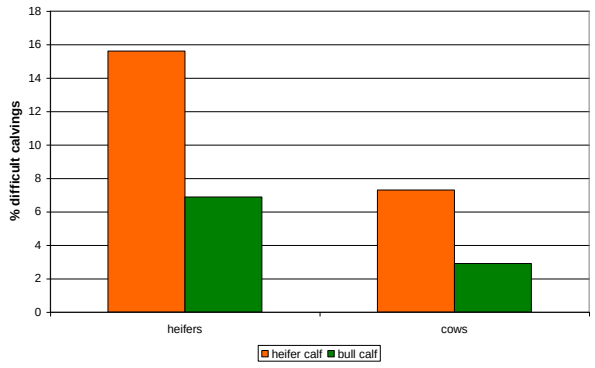

Figure 7. Effect of sex of calf on calving ease

The sex classes are divided into 3-year periods, working back from the earliest calving date in the breeding values estimation, 3-year periods are formed. If the last period is shorter than 2 years, it is combined with the next period. The division into 3-year periods has been carried out in order to take account of changes in the way in which farmers report births over time.

Heterosis and recombination of cow and calf
Heterosis and recombination effects play a role in the combining of breeds. These are genetic effects that are not transmitted to the offspring. Research has shown that a correction must be made for these effects. The amount of the heterosis is defined as the difference in level or the trait in the crossing with the average of the parent breeds. Recombination is the loss of the usually positive effect of heterosis and occurs when the earlier achieved crossing product is crossed back with one of the parent breeds. A distinction is made between the type of cross for both heterosis

and recombination, namely a cross between two dairy breeds, between two beef breeds, between two double muscling breeds, between a dairy breed and a beef breed, between a dairy breed and a double muscling breed, and between a beef breed and a double muscling breed.

Inbreeding of cow and calf
Inbreeding is the making of a mating between two animals whose DNA is more related to each other than the average relatedness in the population. Therefore, inbreeding leads to an increase in homozygosity. By comparing inbred animals with non-inbred animals on a trait, the negative effect of inbreeding can be estimated. Inbreeding is not heritable.

Additive genetic effect for the cow or maternal effect
The additive genetic effect of the cow is the maternal breeding value, the effect that matters in the end. The variable cow contains the (genetic) contribution of a cow to the observation and determines the maternal breeding value of an animal. All of the information concerning ancestors and progeny is also used in determining the breeding value. The heritabilities used are shown in Table 1.

Additive genetic effect for the calf or direct effect
The additive genetic effect of the calf is the direct breeding value, the effect that matters in the end. The variable calf contains the (genetic) contribution of a calf to the observation and determines the direct breeding value of an animal. All of the information concerning ancestors and progeny is also used in determining the breeding value. The heritabilities that are used are shown in Table 1.

Permanent environment effect
A cow can calve several times in her life. The observations within a cow have more in common than genetics. This additional agreement is called permanent environment effect, an effect of the constant conditions in which a cow is kept. By using a permanent environment effect in the model, several observations on an animal can be used in order to obtain a better estimate of breeding value. The heritabilities used are shown in Table 1.

▪ Parameters

A total of six traits are analysed in the breeding value estimation: 3 for heifers and 3 for cows. These are the three traits of calving ease, gestation length and birth weight. These traits are analysed as separate correlated traits for heifers and cows. Because both cow and calf are involved in the birth, an additive genetic effect is estimated for both animals. As a result, two breeding values are obtained for each trait: the direct effect for the calf and the maternal effect for the cow. In the end, breeding values are estimated for 12 traits. Table 1 shows the heritability, repeatability and genetic standard deviation. Heritability is a measure of the fraction that is explained by genetics. Repeatability indicates the part of the observation on an animal that corresponds with a subsequent observation on the same animal. Table 2 shows the genetic correlations.

Table 1. Heritability (h^2), repeatability and genetic standard deviation for the birth traits (1 = heifers, 2+ = cows)

trait	h^2	repeatability	genetic standard deviation	unit
maternal calving ease 1	0.028		0.11	
maternal gestation length 1	0.093		1.05	days
maternal birth weight 1	0.023		0.30	kg
maternal calving ease 2+	0.009	0.038	0.06	
maternal gestation length 2+	0.093	0.126	1.12	days
maternal birth weight 2+	0.026	0.053	0.37	kg
direct calving ease 1	0.071		0.17	
direct gestation length 1	0.441		2.63	days
direct birth weight 1	0.060		0.54	kg
direct calving ease 2+	0.048	0.076	0.11	
direct gestation length 2+	0.410	0.444	2.61	days
direct birth weight 2+	0.075	0.102	0.67	kg

Table 2. Genetic correlations for calving traits on the biologic scale (1=heifers, 2+ =cows)

	maternal calving ease 1	maternal gestation length 1	maternal birth weight 1	maternal calving ease 2+	maternal gestation length 2+	maternal birth weight 2+	direct calving ease 1	direct gestation length 1	direct birth weight 1	direct calving ease 2+	direct gestation length 2+	direct birth weight 2+
maternal calving ease 1												
maternal gestation length 1	0.30											
maternal birth weight 1	0.34	0.32										
maternal calving ease 2+	0.71	0.31	0.52									
maternal gestation length 2+	0.27	0.84	0.20	0.17								
maternal birth weight 2+	0.32	0.36	0.82	0.61	0.31							
direct calving ease 1	0.10	0.06	0.12	-0.02	-0.08	-0.19						
direct gestation length 1	0.20	0.09	0.29	-0.09	0.09	-0.09	0.31					
direct birth weight 1	0.19	0.01	0.07	-0.15	-0.04	-0.18	0.95	0.27				
direct calving ease 2+	0.13	-0.04	-0.10	-0.12	0.06	0.00	0.97	0.54	0.94			
direct gestation length 2+	0.12	0.10	0.28	-0.06	0.07	-0.06	0.36	0.99	0.40	0.47		
direct birth weight 2+	0.01	0.08	0.07	-0.14	0.01	-0.19	0.94	0.54	0.98	0.94	0.49	

▪ Publication

Sire breeding values for Calving Ease and MCP (and also for Gestation Length and Birth Weight) are presented as relative breeding values with an average of 100 and a standard deviation of 4. Breeding values based on heifer calvings are published, because most problems occur around calvings of heifers. The effect on the offspring of a 104 breeding value of a bull mated to an average cow is shown in table 3. The transmitting ability is calculated as half the breeding value and indicates the effect on the offspring.

Table 3. Effect of relative breeding values for calving ease, gestation length and birth weight at first and higher parities (1 = heifers, 2+ = cows)

trait	Relative breeding value	Transmitting ability (effect on offspring)	unit
maternal calving ease 1	104	1.3	%
maternal gestation length 1	104	0.48	days
maternal birth weight 1	104	0.22	kg
maternal calving ease 2+	104	0.5	%
maternal gestation length 2+	104	0.55	days
maternal birth weight 2+	104	0.28	kg
direct calving ease 1	104	1.5	%
direct gestation length 1	104	1.30	days
direct birth weight 1	104	0.43	kg
direct calving ease 2+	104	0.8	%
direct gestation length 2+	104	1.43	days
direct birth weight 2+	104	0.55	kg

There is a difference between the effect at birth for heifers and for higher parities. The unit of the breeding value for the trait of calving ease and MCP is percentage: for gestation length it is days, and for birth weight it is kilograms. A breeding value for calving ease and MCP over 100 means greater ease, so fewer problems. A breeding value for calving ease of 104 means that around 1.5% less difficult births will occur in heifers and the combination of the same bull with the older cows will produce around 0.8% less difficult births. For gestation length as a direct effect, a breeding value of 104 means a gestation length of 1.30 days longer for heifers and 1.43 days longer for cows. For birth weight as a direct effect, a breeding value of 104 means that a calf born to a heifer is 0.43 kg heavier, and 0.55 kg heavier for a calf born to a cow. For breeding values under 100, the opposite applies: more difficult births, shorter gestation length and lower birth weight. For publication requirements, see chapter ‘Publication rules sires’.

▪ Calving index

The two breeding values for direct calving ease and maternal calving ease are used to compute the calving index. The calving index is:

Calving index = 0.08 x (breeding value direct calving ease –100)
+ 0.07 x (breeding value maternal calving ease –100)
+ 0.50 x (breeding value direct vitality –100)
+ 0.75 x (breeding value maternal vitality –100)
+ 0.14 x (breeding value calf survival – 100)
+ 100

▪ Base

See chapter ‘Bases for breeding values and base differences’.