Statistical Indicators
E-43
Breeding value reproduction disorders

▪ Introduction

Animal health is an important topic within herd management in the dairy industry. More and more farmers use animal health record keeping in management, including reproduction disorders. Reproduction disorders have a negative influence on fertility. Besides, a disorder like reduced placenta results in sick animals. The farmer recorded data, which becomes available via management systems, gives the opportunity to develop breeding values to select against reproduction disorders.

▪ Traits and breeding goal

In publications, breeding values for five reproduction disorders are used: retained placenta (RETP), endometritis (ENDO), metritis (METR), cystic ovaries (CYST) and anoestrum (or inactive ovaries) (ANOU). Additionally, the reproduction disorder health index is used.

Reproduction disorders in heifers differ from reproduction disorders in mature cows. Therefore, the disorders in the breeding value estimation are divided into parity 1 and parity 2 or higher (2+). Nevertheless, it is possible to combine the breeding values of parity 1 and parity 2+ into an overall breeding value per disorder.

▪ Data

Observations
Data about reproduction disorders become available as farmer recorded observations in an animal health system. The traits are analysed as a 0/100 score. The data only include the treated animals for the specific disorder: they are categorized as sick (score 100), while all herd mates at that specific moment are categorized as healthy for that disorder (score 0).

Selection data for the breeding value estimation
Data will be used in the breeding value estimation if they meet the following requirements:
1. A cow must be herd book registered (S) and the sire of the cow must be known;
2. Treatments and diagnoses before January 1, 2006 are not included;
3. If treatment and diagnosis are executed or observed before the first known calving date, the data is not included;
4. If various diagnoses are recorded per reproduction disorder per cow-herd-year combination, only one diagnoses per reproduction disorder is included;
5. A minimum of 3% of the animals present on the farm in one year have a diagnosis;
6. For retained placenta only observations until 20 days after calving are included;
7. Age at calving is a minimum of 610 days;

▪ Statistical model

The breeding values for reproduction disorders are estimated using an animal model, according to the BLUP technique (Best Linear Unbiased Prediction). All traits are analysed using the same model, with little differences for parity 1 and parity 2+. More than one observation is possible for parity 2+, due to more lactations. Consequently, a permanent environmental effect is included.

Different statistical models are used for the various parities:

$Y1_{ijkmno} = BJ_i + YM_j + AGE\_C_k + HET_m + REC_n + INT_o + A_p + Error_{ijkmnop}$

$Y2_{ijlmnop} = HYi + YM_j + PAR_l + HET_m + REC_n + INT_o + A_p + PERM_q + Error_{ijlmnopq}$

Where:

$Y1_{ijklmno}$: Observation for reproduction disorder on heifer *p*, within herd-year *i* and in year-month *j*, age at calving *k*, with heterosis effect *m,* recombination effect *n* and inbreeding coefficient *o*;

$Y2_{ijklmnop}$: Observation for reproduction disorder on cow *p*, within herd-year *i* and in year-month *j*, in parity *l*, with heterosis effect *m,* recombination effect *n* and inbreeding coefficient *o*;

HYi : Herd-year *i*;

YM_j : Year-month *j*;

AGE_C_k : Age at calving for heifers *k*;

PAR_l : Parity for cows *k*;

HET_m : Heterosis class *m*;

REC_n : Recombination class *n*;

INT_o : Inbreeding coefficient *o;*

A_o : Additive genetic effect (or breeding value) of animal *p*;

$PERM_p$: Permanent environment effect *q* on animal *p*;

$Error_{ijkmno}$: Errorterm of Y1, which is not explained by the model;

$Error_{ijlmnop}$: Errorterm of Y2, which is not explained by the model.

The effects A, PERM and Error are random effects, the remaining effects are fixed effects.

▪ Effects in the model

1. Herd-year of calving;
2. Year-month of calving;
3. Age at calving for heifers;
4. Parity for cows;
5. Heterosis and recombination effect;
6. Inbreeding coefficient;
7. Cow;
8. Permanent environment effect.

Herd-year of calving
The incidence of reproduction disorders varies from one herd to the next. Within a herd, the situation in relation to the traits can also change. The herd effect is therefore estimated for each year. With that, all of the animals that calved in the same herd in the same year end up being compared to one another.

Year-month of calving
With the analysis of reproduction disorders, period of calving, defined as year-month of calving, is taken into account. Period of calving has an effect on the incidence of reproduction disorders.

Age at calving for heifers
With the analysis of reproduction disorders, consideration is given to the age at calving of the heifer. Age namely has an effect on reproduction disorders. For heifers there are 18 different age categories, with category 1 correcting for age at 20 months or younger. Category 2 through 17 corrects for age at calving from 21 through 37 months. All of the heifers older than 37 months fall into category 18.

Parity for cows
With the analysis of reproduction disorders parity is taken into account. Parity has an effect on the incidence of reproduction disorders. Older cows has more reproduction disorders. All cows with parity 10 or higher fall into the same category.

Heterosis and recombination effect
Heterosis and recombination effects play a role with crossbreeding. They are genetic effects that are not passed on to the offspring. Research showed that corrections need to be made for these effects. The extent of heterosis is defined as the difference in level of the trait in the crossbred with the difference of the parent breeds. Recombination is the loss of the usually positive effect of heterosis and occurs when the earlier obtained crossbred product is crossed back with one of the parent breeds. This is described in E-chapter 7 in more detail.

Inbreeding coefficient
The amount of inbreeding can effect the incidence of reproduction disorders. The higher the inbreeding coefficient the larger the negative effect, this is called inbreeding depression. By including the inbreeding coefficient as an effect in the model, the negative effects of inbreeding on incidence of reproduction disorders are taken into account.

Cow
This is the additive genetic effect of the breeding value, the effect that matters in the end. The variable *animal* contains the (genetic) contribution of an animal to the observation and determines the breeding value of an animal. In addition, when determining the breeding value, all of the information from predecessors and offspring is used as well.

Permanent environment effect
For reproduction disorders, a cow can be scored at various times within a lactation or various times in different lactations (for two or more lactations). The scores within a cow have more in common than just genetics. This extra commonality is called permanent environment effect, an effect of the constant situation in which a cow functions. With the use of a permanent environment effect in the model, various observations on a cow can be used to derive a better estimation of the breeding value.

▪ Parameters

Five reproduction disorders were analyzed (retained placenta, endometritis, metritis, cystic ovaries and anoestrum) in the two lactation groups (lactation 1 and lactation 2+), which make up a total of ten traits. The disorders were analyzed as correlated traits. Heritabilities, repeatabilities, and genetic deviation are shown in Table 1. Heritability is a measure of the fraction explained by genetics. Results are based on univariate analyses for parameter estimation in ASReml. Repeatability is a measure of how much one observation on an animal is in agreement with a next observation on the same animal. Genetic correlations between reproduction disorders per parity are shown in Table 2. Genetic correlations are based on a bivariate analysis in ASReml.

Table 1. Heritability (h^2), repeatability, and genetic deviation for reproduction disorders in parity 1 and 2+.

Trait	Parity	h^2	Repeatability	Genetic deviation
Retained Placenta	1	0.035		5.41
Endometritis	1	0.040		6.57
Metritis	1	0.044		6.72
Cystic ovaries	1	0.024		4.40
Anoestrum	1	0.011		3.31
Retained Placenta	2+	0.037	0.086	6.01
Endometritis	2+	0.027	0.070	5.76
Metritis	2+	0.023	0.059	4.75
Cystic ovaries	2+	0.012	0.065	3.90
Anoestrum	2+	0.022	0.067	5.26

Tabel 2. Genetic correlations (below diagonal) between the reproduction disorders

	RETP 1	ENDO 1	METR 1	CYST 1	ANOU 1	RETP 2+	ENDO 2+	METR 2+	CYST 2+
RETP 1									
ENDO 1	0,72								
METR 1	0,77	0,87							
CYST 1	0,71	0,43	-0,16						
ANOU 1	0,69	0,80	0,83	1,00					
RETP 2+	0,73	0,42	0,35	0,53	0,28				
ENDO 2+	0,64	0,77	0,56	0,40	0,62	0,84			
METR 2+	0,57	0,35	0,44	0,12	0,21	0,87	0,88		
CYST 2+	0,34	0,45	0,38	0,83	0,28	0,46	0,56	0,54	
ANOU 2+	0,62	0,51	0,41	0,75	0,99	0,47	0,59	0,50	0,62

1 is parity 1, 2+ is parity 2 and higher.
RETP is retained placenta, ENDO is endometritis, METR is metritis, CYST is cystic ovaries, ANOU is anoestrum.

▪ Index – reproduction disorders

The breeding values intended for publication are the five overall breeding values for reproduction disorders and a single index reproduction disorders. The overall breeding value per reproduction disorder is calculated from the breeding values for parity 1 and parity 2 and higher (2+):

$$BV_i = 0.41 \times BV_{i1} + 0.59 \times BV_{i2+}$$

in which:
BV_i : Breeding value for reproduction disorder i.

The derivation of the factors (0.41 and 0.59) are described in E-chapter 7. The weighting factors for the first three lactations from the testday model are used. For each reproduction disorder, a distinction is made between parity 1 and parity 2 and higher. For this reason the weighting factors of lactations 2 and 3 (0.33 and 0.26) are added together.

In table 3 the heritabilities and genetic deviations are shown for the overall traits for reproduction disorders.

Table 3. Heritabilities (h^2) and genetic deviation for the overall traits for reproduction disorders.

Trait	h^2	Genetic deviation
Retained Placenta	0.07	5.28
Endometritis	0.06	5.54
Metritis	0.05	4.58
cystic ovaries	0.03	3.71
Anoestrum	0.04	4.22

The average prevalence, average cost, genetic deviation and the relative weight per reproduction disorder is indicated in Table 4. The average costs are based on an estimate of economic values. This is an estimate, because economic costs per reproduction disorders differs a lot in literature. The costs metritis are higher than the costs for retained placenta. The costs for retained placenta are higher then the costs for the other three disorders. The costs for metritis are estimated between $106 and $ 278 (Bartlett et al., 1986a; Liang et al., 2017; Donnelly, 2017; Yildiz, 2018). The costs for retained placenta are estimated between $27 and $257 (Donnelly, 2017; Guard et al., 2008; Liang et al., 2017; Yildiz, 2018). The costs for cystic ovaries are estimated between $16 and $137 (Donnelly, 2017; Bartlett et al., 1986b). For endometritis and anoestrum no indicative costs were available. Therefor these were estimated in the same range as the costs for cystic ovaries. Treatments for these three disorders were of comparable level.

Based on the costs mentioned above, the following costs estimations for the reproduction disorders are made: €100,- for metritis, €60,- for retained placenta and €40,- for the other reproduction disorders. For the index calculation the traits are weighed in the ratio 3:2:5:2:2. The relative weight is the proportion of the relative breeding value for the individual reproduction disorders in the index. This is based on costs and genetic deviation of the trait. Based on the costs estimation the genetic deviation of the index reproduction disorders is €11.61. The relative weights of the index are calculated straightforward because the index is published on the same relative scale.

Table 4. Average prevalence, average cost, genetic deviation, absolute weight and relative weight per reproduction disorder

Trait	Prevalence	Cost (€)	Genetic deviation	Relative weight
Retained Placenta	10%	60	5.28	0.27
Endometritis	13%	40	5.54	0.20
Metritis	10%	100	4.58	0.43
cystic ovaries	12%	40	3.71	0.13
Anoestrum	14%	40	4.22	0.13

The index reproduction disorders is derived from the five relative overall indexes for reproduction disorders according to the formula:

$BV_{rep.rel}$ = 100 + 0.27 x (BV_{RETP} – 100) + 0.20 x (BV_{ENDO} – 100) + 0.13 x (BV_{CYST} – 100) + 0.13 x (BV_{ANOES} – 100) + 0.43 x (BV_{METR} – 100)

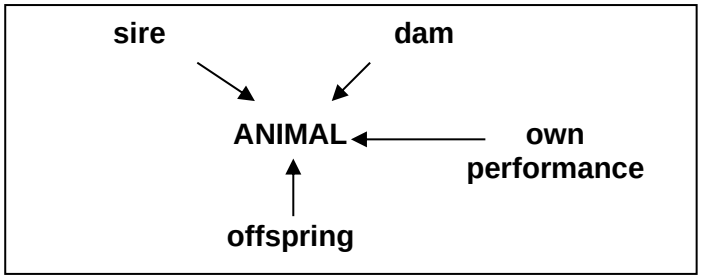
This relative breeding value or index, just like the breeding values for the five reproduction disorders, has an average of 100 and a standard deviation of 4.

▪ Reliability

Breeding values are estimations of genetic potential. The word ‘estimation’ indicates that there is a certain inaccuracy in a breeding value. The reliability of a breeding value indicates the amount of difference that can exist between the estimated breeding value and the true genetic value.

The reliability is dependent on the amount of information available from an animal. There are three information sources:

1. own performance
2. offspring
3. parents



Information for reproduction disorders of (half) sisters, grandparents, etc. is included via the parents; information about granddaughters etc. are included via the offspring.

▪ Base

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

▪ Publication

Presentation

The breeding values for the reproduction disorders are presented with an average of 100 and a standard deviation of 4. With this it is important to keep in mind that figures above 100 are desirable. An index for reproduction disorders of more than 100 indicates that reproduction disorders will occur *less* frequently in the daughter group.

Publication requirements

See chapter ‘Publication rules sires’.

▪ Literature

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