Statistical Indicators
E-30
Claw Health Index

Introduction

Claw disorders and lameness, together with mastitis and declining fertility, are the most important management challenges facing the Dutch dairy industry. Claw disorders and lameness are not only costly for the dairy farmer but also have a big impact on animal welfare. More than 70% of cows have one or more claw disorders (Van der Waaij *et al.*, 2005).

In free stall barns, unhealthy claws and poor locomotion of animals also have an effect on feed intake and production. In addition, there are costs associated with curative treatment of the animals and preventative measures taken to prevent claw disorders.

In the Netherlands, hoof trimming, both curative and preventative, is generally speaking, a common management practice among dairy farmers. Hoof trimming is often done by specialists, hoof trimmers.

Hoof trimmers from the Agrarische Bedrijfsverzorging (Agricultural Assistance Association) and the Vereniging voor rundveepedicure (VvRVP - Association for Cattle Pedicure) routinely collect data at the time of hoof trimming. They do this with the assistance of the so-called Digiklauw program. This program was initiated in September 2006 and one of the options is to enter digital data about cows and claw disorders from cows treated by hoof trimmers. This data is recorded with a PDA, sent to CRV, and entered into a database.

The environment (barn type, floor type) has a lot of influence on hoof quality and the prevention of disorders. In addition, management also plays a big role, with, for example, the ration, preventative health care, and the use of foot baths having an influence on claw health. Besides these external factors, genetics also play a role. Claw disorders turn out to be heritable. The heritability may then be small compared to other traits, however there is sufficient variation in the population. Claw disorders and lameness have enough financial impact that it is useful to select for it in the breeding of animals.

Now that a lot of data about claw disorders is becoming available, it is useful to develop breeding values for the most important claw disorders and to combine these claw disorders in a claw health index. By selecting on this claw health index, it is possible to reduce the prevalence of claw disorders in the herd and this should result in fewer lame cows in the future.

▪ Definition of claw health

What is a healthy claw? A healthy claw is a claw without defects such as injury, unbalanced horn formation, lesions, and infections. Claw disorders can be distinguished as acute or chronic, depending on the speed at which they develop, seriousness, response to treatment, and the time needed for recovery. Many types of claw disorders can be identified. The most prominent in the Dutch dairy cattle population are: sole haemorrhage, digital dermatitis, interdigital dermatitis, sole ulcer, interdigital hyperplasia, and white line disease.

Since there are so many claw disorders, the claw health index was developed as a means of breeding for the prevention of claw disorders. In other words, the claw health index needs to assist in breeding a cow that is less susceptible to all claw disorders. In the claw health index all of the information about claw disorders is combined in one number, one index. This makes it easier to select for claw health.

▪ Traits and Breeding Goals

In publications, breeding values for six claw disorders and the claw health index are used: sole haemorrhage, digital dermatitis, interdigital dermatitis, sole ulcer, interdigital hyperplasia, white line disease and the claw health index in which the six claw disorders are weighed according to their economic cost. The six claw disorders as used in the claw health index thus form the breeding goal.

Besides the six claw disorders, there are also five feet and leg conformation traits that are used in the breeding value estimation. They include rear leg rear view, rear leg side view, foot angle, locomotion, and feet & legs. In the breeding value estimation, the claw disorders are divided into parity 1 and parity 2 or higher. In this way the total number of traits in the breeding value estimation for claw health ends up at seventeen (2 x 6 claw disorders + 5 feet and leg conformation traits).

Claw health traits

Sole Haemorrhage
Sole haemorrhage becomes visible due to changes in horn formation and the shape of the claws. These changes are: an indented fore curb, growth rings becoming further and further apart towards the heel bulb, yellow or red colouring of the horn of the sole, defects in the white line, and the appearance of sole ulcers.

Digital Dermatitis (Mortellaro)
Mortellaro – also called strawberry foot rot – is a skin disorder at the skin-horn junction which is caused by various bacteria. The disease often expresses itself as round skin injuries with a strawberry-type surface just above the coronary band.

Interdigital Dermatitis (Foot rot)
This disorder can be acute, sub-acute, or chronic. In the first phase the epidermis is affected, which results in an infection in the skin of the cleft, which sometimes coincides with heel erosion and excessive horn formation outside of the heel area. The second phase is characterized by overloading of the dermis as the result of excessive horn formation.

Sole Ulcer
Presence of an ulcer and other possible infections. When knocking on the sole, there is often a pain reaction. The dermis is bruised, with irregular horn formation, and the heel area is painfully red and swollen.

Interdigital Hyperplasia (Tyloma or Corns)
Interdigital hyperplasia is a tumour-like growth of tissue (wild tissue). The tissue that results can extend to the front or into the hoof cleft. This chronically infected tissue subsequently grows rampantly with an increasing protrusion emerging between the claws.

White line defect
Separation of the tissue (white line) between the sole and claw wall. Due to this separation, the dermis becomes infected which results in abscess formation. Clinical inspection of the sole at an early stage reveals redness in the white line. The most notable aspect of a white line disorder is that one portion of the ball area swells up.

▪ Data

Observations

Data about claw disorders becomes available in two different ways, namely via treatment and by way of disorders. Observations about treatment are available for all cows that have been trimmed by a hoof trimmer. Observations about disorders are available for all cows from which the hoof trimmer has recorded at least one disorder.
Claw disorders can be recorded as a categorical trait or as a binary trait. Interdigital hyperplasia and white line disease are scored as binary (0/1) traits. Sole haemorrhage, digital dermatitis, interdigital dermatitis, and sole ulcers are scored as categorical traits. The following categories are used:
0 – no disorder
1 – slight disorder
2 – moderate disorder
3 – severe disorder
The observations onto account for the differences in frequency distribution of the different categories. The transformation is stratified through claw disorder by hoof trimmer by year of trimming.
The transformation is conducted as follows. Per claw disorder, per hoof trimmer, per year of trimming, the frequency of the 4 different categories is calculated. Afterwards, this frequency is transformed into a corresponding x-co-ordinate of the underlying standard normal distribution which coincides with this frequency. This transformed value is used in the breeding value estimation.

Selection data for the breeding value estimation

Claw data is used in the breeding value estimation when they meet the following requirements:
1. A cow must be herd book registered (S) and the sire of the cow must be known;
2. Treatment and diagnoses before October 1, 2006 are not included;
3. If the number of days between successive treatments and the diagnosis is less than 7 days, the observations are combined on animal level;
4. If treatment and diagnosis are executed or observed before the first known calving date, the data is not included;
5. If various treatments or diagnoses are recorded per claw disorder per cow-herd-trimming date combination, then only the treatment or diagnosis is included from the hoof trimmer with the lowest identification number;
6. A minimum of 20% of the animals present on the farm are trimmed per herd-day;
7. A minimum of 50% of the animals present on the farm in one year are trimmed, if requirement 6 is not met.

8. Minimum number of treated animals per herd-day is 10;
9. The number of average claw disorders per cow per trimming per herd-day had to be a minimum of 0.10 diagnoses and a maximum of 3.00 diagnoses per treatment;
10. Only treatment and diagnoses up to and including 550 days after calving are included;
11. The minimum age at first calving has to be 640 days;

Requirements for conformation data are:

12. A cow needs to be herd book registered (S) and the sire of the cow must be known;
13. The cow must have a known calving date and be a two-year-old at the time of classification;
14. The conformation scores are included when the score for rear leg rear view is known;
15. Only type scores between days 14 and 550 after calving are included;
16. Age at calving is a minimum of 640 days and a maximum of 3 years;
17. The classification has to be conducted during herd classification or selective classification.

▪ Statistical model

The breeding values for claw health traits are calculated with an animal model, following the BLUP technique (Best Linear Unbiased Prediction). At the same time the conformation scores for feet & legs during the first lactation are analysed. For that, correlation between all traits is used. The breeding value estimation is thus a 'multiple trait' breeding value estimation. The reason for including the conformation scores in the breeding value estimation is that these traits are good predictors of claw health. By including these five predictors, the reliability of the claw health breeding values will increase.

Different statistical models are used for the various traits:

$$Y1_{ijklmnopq} = HTD_i + HTHJ_j + T\_AGE_k + T\_LACT_l + HET_m + REC_n + A_o + PERM_p + Rest_{ijklmnopq}$$
$$Y2_{ijklmnopq} = HTD_i + HTHJ_j + PAR_k + T\_LACT_l + HET_m + REC_n + A_o + PERM_p + Rest_{ijklmnopq}$$
$$Y3_{abcmnop} = HCD_a + C\_AGE_b + C\_LACT_c + HET_m + REC_n + A_o + Rest_{abcmnop}$$

in which

$Y1_{ijklmnopq}$: Observation of claw disorder on heifer *o*, with herd-treatment date *i* and in hoof trimmer-half year *j*, age at hoof trimming *k* and stage of lactation at hoof trimming *l*, with heterosis effect m and recombination effect *n*;

$Y2_{ijklmnopq}$: Observation of claw disorder on cow *o*, with herd-treatment date i and in hoof trimmer-half year *j*, parity *k* and stage of lactation at hoof trimming *l*, with heterosis effect *m* and recombination effect *n*;

$Y3_{abclmnop}$: Observation for conformation score on cow *o*, on herd-classification date *i*, age at classification *k* and stage of lactation at classification *l*, with a heterosis effect *m* and recombination effect *n*;

HTD_i : Herd treatment date *i*;

HCD_a : Herd classification date *a*;

$HTHJ_j$: Hoof trimmer-half year *j*;

T_AGE_k : Age at time of treatment *k*;

C_AGE_b : Age at classification *b*;

PAR_k : Parity *k*;

BT_LACT_l : Lactation stage at time of treatment *l*;

C_LACT_c : Lactation stage at classification *c*;
HET_m : Heterosis class *m*;
REC_n : Recombination class *n*;
A_o : Additive genetic effect (or breeding value) of animal *o*;
$PERM_p$: Permanent environment effect on animal *o*;
$Rest_{ijklmnopq}$: Restterm of $Y1_{ijklmnopq}$ and $Y2_{ijklmnopq}$ which is not explained by the model;
$Rest_{abcmnop}$: Restterm of $Y3_{abcmnop}$ which is not explained by the model.

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

The effects in the model

The effects in the model are:

1. Herd treatment date;
2. Herd classification date;
3. Hoof trimmer-half year;
4. Age at time of treatment;
5. Age at classification;
6. Parity;
7. Lactation stage at time of treatment;
8. Lactation stage at time of classification;
9. Heterosis;
10. Recombination;
11. Cow;
12. Permanent environment effect.

Herd treatment date
The level of hoof scores 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 day that the hoof trimmer or the hoof trimmers score the animals. With that, all of the animals that are scored in the same herd on the same day end up being compared to one another.

Herd classification date
Conformation scores vary from one herd to the next. Within a herd, the situation in relation to the traits can also change. The herd effect for conformation traits is therefore estimated for each day that the classifier scores animals. With that, all of the animals that are scored in the herd on the same day end up being compared to one another.

Hoof trimmer-half year
In the case that various hoof trimmers have scored animals in a herd on the same day, the hoof trimmer-half year effect takes into account a possible difference in scores by various hoof trimmers. Treatment and diagnoses of hoof trimmers with less than 100 scores per half year are combined into one category.

Age at time of treatment
With the analysis of claw disorders, consideration is given to the age of the animal at the time of treatment. Age namely has an effect on claw disorders. There are 18 different age categories, with

category 1 correcting for age at 24 months or younger. Category 2 through 17 corrects for age at claw treatment from 25 through 40 months. All of the cows older than 41 months fall into category 18.

Age at classification
With the analysis of the feet & leg conformation traits, consideration is given to the age of the animals at the time of classification. Age namely has an effect on conformation scores. There are 18 different age categories, with category 1 correcting for age at 24 months or younger. Category 2 through 17 corrects for age at classification from 25 through 40 months. All of the cows older than 41 months fall in category 18.

Lactation stage at time of claw treatment
With the analysis of the claw disorders, lactation stage (number of months that a cow is in lactation) at the time of claw treatment is taken into account. Lactation stage namely has an effect on claw disorders. Eighteen stages of lactation are distinguished, one for each month in lactation.

Lactation stage at time of classification
With the analysis of the feet & leg traits, lactation stage (number of months that a cow is in lactation) at the time of classification is taken into account. Lactation stage namely has an effect on conformation scores. Eighteen stages of lactation are distinguished, one for each month in lactation.

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.

The heterosis effect (HET) of two breeds can be calculated using the formula:

$$HET = [p_s(1-p_d) + p_d(1-p_s)]$$

in which:

p_s = breed blood portion of sire
p_d = breed blood portion of dam

The formula for recombination (REC) is as follows:

$$REC = [p_s(1-p_s) + p_d(1-p_d)]$$

When an animal consists of three different breeds, the number of effects of heterosis and recombination increases as well.

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
For claw 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.

▪ Traits

In total, in the claw health breeding value estimation, 12 claw traits are analysed, being 6 claw disorders (sole haemorrhage, digital dermatitis, interdigital dermatitis, sole ulcer, interdigital hyperplasia, and white line disease) in 2 lactation groups (lactation 1 and lactation 2+). Besides the 12 claw traits, information about the feet & leg classification traits from the time of herd classification are used. The heritabilities, repeatability, and genetic deviation are shown in Table 1. The heritability is a measure of the fraction explained by genetics. The repeatability is a measure how much of one observation is in common with a next observation on the same animal. Feet & leg conformation traits are used in the breeding value estimation because this information is recorded for more animals than just the animals that are hoof trimmed. Also the genetic correlations with claw disorders are reasonable and therefore the reliability of the claw health index increases when conformation information is available. Genetic correlations and error correlations are shown in Table 2 and permanent environment correlations are shown in Table 3.

Table 1. Heritability (h^2), repeatability, and genetic deviation for the traits

Trait	h^2	repeatability	genetic deviation
Sole haemorrhage 1	0.07	0.15	0.196
Digital dermatitis 1	0.09	0.36	0.222
Interdigital dermatitis 1	0.08	0.21	0.180
Sole ulcer 1	0.08	0.30	0.116
Interdigital hyperplasia 1	0.08	0.42	0.089
White line disease 1	0.03	0.14	0.075
Sole haemorrhage 2+	0.05	0.17	0.165
Digital dermatitis 2+	0.08	0.30	0.190
Interdigital dermatitis 2+	0.11	0.27	0.239
Sole ulcer 2+	0.12	0.30	0.191
Interdigital hyperplasia 2+	0.14	0.62	0.184
White line disease 2+	0.03	0.17	0.096
Rear leg rear view	0.18		0.659
Rear leg side view	0.24		0.725
Foot angle	0.20		0.640
Locomotion	0.12		0.532
Feet & legs	0.17		1.332

Table 2. Genetic correlations (below diagonal) and error correlations (above diagonal) between the traits

	Sole haemorrhage 1	Digital dermatitis 1	Interdigital dermatitis 1	Sole ulcer 1	Interdigital hyperplasia 1	White line disease 1	Sole haemorrhage 2+	Digital dermatitis 2+	Interdigital dermatitis12+	Sole ulcer 2+	Interdigital hyperplasia 2+	White line disease 2+	Rear leg rear view	Rear leg side view	Foot angle	Locomotion	Feet & legs
Sole haemorrhage 1		-0.02	0.00	0.01	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Digital dermatitis 1	0.08		-0.02	0.02	0.07	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interdigital dermatitis1	0.17	0.77		0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sole ulcer 1	0.60	0.00	0.05		-0.02	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interdigital hyperplasia 1	0.17	0.44	0.37	0.04		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White line disease 1	0.20	-0.31	-0.18	0.51	-0.08		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sole haemorrhage 2+	0.82	0.07	0.07	0.68	-0.07	0.34		0.01	0.01	0.01	0.01	0.04	0.00	0.00	0.00	0.00	0.00
Digital dermatitis 2+	-0.12	0.81	0.42	-0.06	0.28	-0.25	0.03		-0.03	-0.01	0.04	-0.02	0.00	0.00	0.00	0.00	0.00
Interdigital dermatitis 2+	0.08	0.82	0.85	-0.07	0.45	-0.19	0.06	0.58		-0.02	0.04	-0.02	0.00	0.00	0.00	0.00	0.00
Sole ulcer 2+	0.59	0.09	-0.09	0.82	-0.01	0.46	0.79	0.11	0.00		-0.02	-0.02	0.00	0.00	0.00	0.00	0.00
Interdigital hyperplasia 2+	0.06	0.63	0.50	-0.06	0.77	-0.30	0.06	0.60	0.65	0.01		0.00	0.00	0.00	0.00	0.00	0.00
White line disease 2+	0.12	-0.29	-0.24	0.41	-0.12	0.77	0.45	-0.11	-0.05	0.58	-0.03		0.00	0.00	0.00	0.00	0.00
Rear leg rear view	0.14	-0.33	-0.26	-0.12	-0.29	0.02	0.10	-0.18	-0.13	-0.11	-0.27	0.12		-0.18	0.31	0.48	0.56
Rear leg side view	0.11	0.14	0.27	0.36	0.07	-0.07	-0.05	0.05	0.08	0.14	0.10	-0.11	-0.26		-0.40	-0.17	-0.25
Foot angle	-0.05	-0.13	-0.24	-0.22	-0.18	0.23	0.09	0.15	-0.09	-0.09	-0.15	0.16	0.38	-0.73		0.29	0.40
Locomotion	-0.20	-0.56	-0.48	-0.25	-0.37	0.00	-0.14	-0.31	-0.39	-0.30	-0.35	0.09	0.79	-0.41	0.44		0.80
Feet & legs	-0.20	-0.51	-0.41	-0.21	-0.38	0.05	-0.12	-0.28	-0.36	-0.29	-0.37	0.07	0.76	-0.49	0.53	0.92	

Table 3. Permanent environment correlations between the traits

	Sole haemorrhage 1	Digital dermatitis 1	Interdigital dermatitis 1	Sole ulcer 1	Interdigital hyperplasia 1	White line disease 1	Sole haemorrhage 2+	Digital dermatitis 2+	Interdigital dermatitis 2+	Sole ulcer 2+	Interdigital hyperplasia 2+
Sole haemorrhage 1											
Digital dermatitis 1	0.06										
Interdigital dermatitis1	0.09	0.62									
Sole ulcer 1	0.61	-0.06	0.18								
Interdigital hyperplasia 1	0.00	0.11	0.32	0.10							
White line disease 1	0.33	-0.11	-0.17	0.19	-0.01						
Sole haemorrhage 2+	0.86	-0.05	-0.10	0.32	0.13	0.31					
Digital dermatitis 2+	-0.07	0.70	0.45	-0.07	0.02	-0.16	-0.06				
Interdigital dermatitis 2+	0.13	0.67	0.88	0.01	0.24	-0.08	0.01	0.49			
Sole ulcer 2+	0.85	0.07	0.29	0.87	0.18	0.18	0.59	-0.03	0.18		
Interdigital hyperplasia 2+	0.10	0.23	0.28	-0.03	0.88	0.00	0.29	0.13	0.27	0.16	
White line disease 2+	0.36	0.05	-0.14	0.22	-0.02	0.83	0.31	-0.05	-0.04	0.18	0.00

▪ Claw health index

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

$$FW_i = 0.41 \times FW_{i1} + 0.59 \times FW_{i2+}$$

In which:

FW_i : index for claw 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 claw 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 4 the heritabilities and genetic variance are shown for the overall traits for claw disorders.

Table 4. Heritabilities (h^2) and genetic variance for the overall traits for claw disorders. The genetic variance is on a scale in which the scores are transformed to a normal distribution with a standard deviation of 1.0.

Trait	h^2	Genetic deviation
Sole haemorrhage overall	0.09	0.170
Digital dermatitis overall	0.12	0.193
Interdigital dermatitis overall	0.14	0.207
Sole ulcer overall	0.15	0.154
Interdigital hyperplasia overall	0.14	0.139
White line disease overall	0.04	0.082

In the claw health index the economic costs are included for the six claw disorders. The average economic cost of the six claw disorders are indicated in Table 5 (Bruijnis *et al.*, 2009). With this, both direct and indirect costs are taken into account. Direct costs may include reduced milk

revenue, treatment costs, and culling costs. Indirect costs include reduced fertility and other disorders. Also shown in table 5 per claw disorder are the average prevalence, prevalence per genetic deviation, costs per genetic deviation, genetic deviation, the absolute and relative weight in the claw health index and the genetic deviation of the index itself.

Table 5. Average prevalence, average cost, prevalence per genetic deviation, cost per genetic deviation, genetic deviation, absolute weight in claw health index and relative weight in claw health index per claw disorder

Trait	prevalence	cost	prevalence per gen.dev.	costs per gen.dev.	gen.dev.	absolute weight	relative weight
Sole haemorrhage	38%	€ 55	6.9%	€ 3.81	16.96	0.225	0.362
Digital dermatitis	22%	€ 68	6.1%	€ 4.16	19.32	0.215	0.395
Interdigital dermatitis	29%	€ 57	7.9%	€ 4.48	20.70	0.216	0.425
Sole ulcer	7%	€ 79	2.4%	€ 1.87	15.44	0.121	0.177
Interdigital hyperplasia	5%	€ 66	1.6%	€ 1.08	13.86	0.078	0.102
White line disease	11%	€ 58	1.7%	€ 0.99	8.23	0.120	0.094
Claw health index					10.54		

On the absolute scale the breeding values of the claw disorders are expressed as transformed scores on the underlying scale with a standard normal distribution ~N(0,100). These values can be transformed back into prevalences. One genetic deviation on the relative scale (4 points) is similar with a change of the prevalence divided by the genetic deviation. The according costs/savings are the prevalence per genetic deviation multiplied with the costs of a claw disorder. The prevalence per genetic deviation is 6.9% for sole haemorrhage. The costs per genetic deviation of sole haemorrhage is €55 x 6.9% = €3.81.

However, all breeding values for claw disorders and the claw health index are published as relative breeding values with an average of 100 and a standard deviation of 4. Therefore the weightings of the underlying breeding values for claw disorders need to be converted to a relative scale. The weightings are determined by the economic cost of each of the claw disorders.
The genetic deviation of the claw health index is €10.54. The relative weights of the index are calculated straightforward because the index is published on the same relative scale.

Example:
$W_{rel,sole}$ heamorrhage = deviation sole heamorrhage € / deviation index € = € 3,81 / € 10,54 = 0,362

The claw health index is derived from the six relative overall indexes for claw disorders according to the formula:

$$FW_{clw,rel} = 100 + 0.362 \times (FW_{sole\ haemorrhage} - 100) + 0.395 \times (FW_{digital\ dermatitis} - 100) + 0.425 \times (FW_{interdigital\ dermatitis} - 100) + 0.177 \times (FW_{sole\ ulcer} - 100) + 0.102 \times (FW_{interdigital\ hyperplasia} - 100) + 0.094 \times (FW_{white\ line\ disease} - 100)$$

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

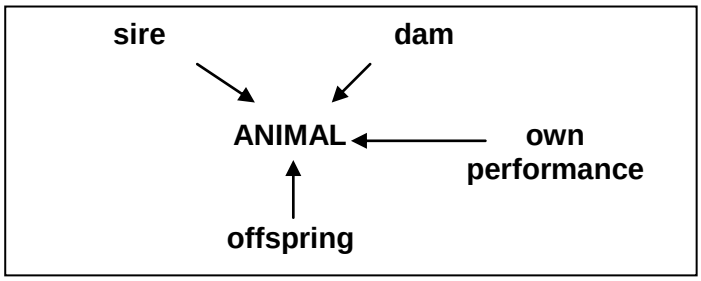
▪ Reliability

Breeding values are estimations of genetic potential. The word ‘estimation’ indicates that there is a certain inaccuracy in a breeding value. The reliability of an ina 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 claw health of (half) sisters, grandparents, etc. is included via the parents; information about granddaughters etc. are included via the offspring.



In table 6 the expected reliabilities for sires in different categories are shown. A young sire with classified daughters for conformation of feet & and leg traits only gets a reliability of 24%. A young sire will get a reliability of around 39% when he receives his first index. After finishing the first lactation the reliability will increase to 59%. Without classified daughters this would be 52%. Adding conformation as information source increases the reliability with 7%. When the second crop daughters come into production the reliability will be around 87% and with many daughters the reliability is 96% or higher. Conformation scores hardly contribute to the reliability for sires with second crop daughters. These reliabilities are a lower limit, because reliabilities could be higher because pedigree information.

Table 6. Reliability of claw health index for different categories of sires. Total number of daughters is the number of daughters participating in the milk recording, 60% of those are classified and 10% those are hoof trimmed.

	Number of daughters			
	total	classified	trimmed	reliability
Young sire with classified daughters only	150	90	-	24%
Proven sire with classified daughters only	5,000	3,000	-	35%
Ypung sire with 1st claw health index	50	30	5	39%
Young sire with daughters at the end of 1st lactation	150	90	15	59%
- without classified daughters	150	-	15	52%
Proven sire with hooftrimmed and classified daughters	1,000	600	100	87%
- without classified daughters	1,000	-	100	85%
Proven sire with many hooftrimmed and classified daughters	5,000	3,000	500	96%
- without classified daughters	5,000	-	500	96%

▪ Base

Breeding values for claw health are presented using a single basis, specifically the black & white basis.

Black & white basis

Herd book registered cows born in 2005 with a minimum of 87.5% HF blood and 12.5% or less FH blood and a black & white hair coat, with at least one observation in the breeding value estimation.

An observation is an observation for at least one of the six claw disorders. Every five years, in a year which can be divided by 5, the reference year for the basis is moved up 5 years.

The standard deviation of the breeding values is determined by the animals of the black & white basis. The standard deviation of the breeding values from the base animals is calculated followed by a standardisation of this standard deviation to an average reliability of 80% for the breeding values. This means that a 4 point standard deviation is comparable to 0.9 x genetic standard deviation.

▪ Publication

Presentation

The breeding values for the claw health traits 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 claw health of more than 100 indicates that claw disorders will occur *less* frequently in the daughter group. The effect on the offspring of a 104 breeding value of a bull mated to an average cow is shown in table 7. The transmitting ability is calculated as half the breeding value and indicates the effect on the offspring.
A breeding value 104 for the claw health index results in cows with 2.8% claw disorders. For sole haemorrhage, digital dermatitis and interdigital dermatitis a breeding value of 104 will reduce these claw disorders by about 3%. For sole ulcer, interdigital hyperplasia and white line disease a breeding value of 104 will reduce these claw disorders by about 1%.

Table 7. Effect of relative breeding values for claw disorders and the claw health index on offspring

Trait	Relative breeding value	Transmitting ability (effect on offspring)
Sole haemorrhage	104	-3.1%
Digital dermatitis	104	-2.7%
Interdigital dermatitis	104	-3.5%
Sole ulcer	104	-1.1%
Interdigital hyperplasia	104	-0.7%
White line disease	104	-0.8%
Claw health index	104	-2.8%

Publication requirements

The publication requirement for all bulls is a minimum reliability of 30% for the claw health index. For sampled AI bulls, the index is based on a minimum of one descendant. Bulls are considered AI bulls when they have an AI code and an owner who is not registered as a farmer. For non-AI bulls, the minimum requirement is 10 descendants. At the time of publication of the claw health index, the overall underlying breeding values for claw disorders are also published. See Chapter E-26 for further information about publication rules.

Literature

Bruijnis, M.R.N., H. Hogeveen and E.N. Stassen. 2009. Assessing the economic consequences of foot disorders in dairy cattle using a stochastic model. *Submitted* to Journal of Dairy Science.

Van der Linde, C., G. de Jong, E.P.C. Koenen and H. Eding. 2010. Claw health index for Dutch dairy cattle based on claw trimming and conformation data. Journal of Dairy Science 93: 4883-4891.

Van der Waaij, E.H., M. Holzhauer, E. Ellen, C. Kamphuis and G. de Jong. 2005. Genetic parameters for Claw Disorders in Dutch Dairy Cattle and Correlations with Conformation Traits. Journal of Dairy Science 88: 3672-367.