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E-40
Breeding value dry matter intake

▪ Introduction

Dairy cows use feed for the production of milk, for maintenance and to grow. The feed intake of a cow depends on the amount of milk produced, the composition of the milk, as well as body weight and growth. Breeding values for milk production traits have been used for years in the selection of animals. Breeding values for body weight are also known, using a number of conformation traits (E-Chapter 21).

Milk production and body weight can be used to calculate how much feed a cow needs by using the genetic correlations. But it is also possible to measure the feed intake. From this dry matter intake, a breeding value can be calculated. The breeding value based on these two sources may then serve to determine to what extent an animal uses the feed efficiently, i.e. how much milk the animal will produce from this.

This chapter provides further information about the breeding value estimation for dry matter intake.

▪ Data

For the breeding value estimation, dry matter intake data are used from Holstein-Friesian cows that have calved since 1990. These are data of cows that were part of research and were collected on a number of dairy farms in the Netherlands.

Before using the dry matter intake data in the genetic evaluation, the following consecutive edits are applied:

1. If no information is available on the feed trial and treatment, the herd number is used as experiment and the quarter + year is used as treatment. An experimental treatment is a combination of experiment and treatment.

2. The dry matter intake should be at least 8 kg and at most 55 kg per cow per day.

3. As dry matter percentage for concentrates 89% should be used.

4. The average dry matter intake of the herd should be at least 10kg and at most 40 kg per day.

5. For standardization of dry matter intake, a cow should have a body weight of at least 300 kg and at most 1000 kg. For the national genetic evaluation, it is not important whether a cow has an observation on body weight, it will be included anyways.

6. The average body weight of the herd should be at least 500 kg and at most 800 kg

7. The weekly average dry matter intake and body weight is based on at least three daily measurements.

8. A week average/measurement is computed by dividing the weekly amount of dry matter intake (per lactation per cow) by the number of days in that week.

9. A cow should have at least three measurements a week per lactation.

10. At least five cows are measured in an experimental treatment.

11. The first breed of the cow is Holstein-Friesian or Dutch Friesian, independent of the percentage of that breed. Therefore, the cow should be at least 50% Holstein-Friesian or Dutch Friesian.

12. Standardizing of dry matter intake (statistical model is explained in chapter 'Standardizing dry matter intake').

13. Experimental treatments were selected based on their CV (> 0.5 and < 2.25) and correction factor (> 0.04 and <0.2). These are experimental treatments in which dry matter intake is not reliable.
14. Dry matter intake of the first six lactations is used, where lactation 4, 5 and 6 are being used as repeated measurement of lactation 3.
15. Per experimental treatment at least 5 cows are available.

In 2021, the analysis was performed on about 8000 cows with weekly measurements for dry matter intake, between 1 and 53 weeks per lactation. The dry matter intake trait is measured in kilograms of dry matter.
In addition, in the breeding estimation, data are used from a number of predictors, being daily milk, fat and protein productions, as well as weight.
A cow is included in the breeding value estimation when she is herdbook registered, meaning that her pedigree is recognised.

▪ Standardizing dry matter intake

Correction for heterogeneous of variance is applied for each experimental treatment by fitting a residual per experimental treatment. The original (not standardized) weekly dry matter intake is used in a model without permanent environment effect

$$Y = MILK + FAT + PROTEIN + LW + EXP + HM + HY + AGE + LACTSTAGE + BR + A + error$$

where:

Y	:	Observation on animal;
MILK	:	Milk production (kg)
FAT	:	Fat production (kg)
PROTEIN	:	Protein production (kg)
LW	:	Live weight (kg)
EXP	:	Experimental treatment, a combination of experiment and treatment;
HM	:	Herd*month of calving;
HY	:	Herd*year of calving;
AGE	:	Age at calving;
LACTSTAGE	:	Stage of lactation;
BR	:	Second breed percentage of animal;
A	:	Breeding value of animal;
error	:	Error-term of Y, part which is not explained by the model.

The residual variance of each experimental treatment is used to determine the correction factor to standardize the dry matter intake.

The correction factor is computed as:

$$\text{Correction factor} = \sqrt{\frac{Weighted\ average\ residual\ variance}{Residual\ variance\ experiment}}$$

The weighted average residual variance was calculated to correct for the number of animals per experiment/data source. There are two weighted averages calculated:
1. Weighted average of the residual variance of experiments from Schothorst Feed Research and ILVO.
2. Weighted average of the residual variance of experiments from all other data sources except for Schothorst Feed Research and ILVO.

Standardization of dry matter intake:

Standardized dry matter intake = non-standardized dry matter intake * correction factor

▪ Statistical model

Calculation of breeding values for dry matter intake is done using an animal model, according to the BLUP technique (Best Linear Unbiased Prediction). For the breeding value estimation, the genotypes of the animals are used as well, allowing a better determination of the relationships between the animals. The breeding values from the estimation are the result of observations, pedigree information and genotype information from the cow or, if the cow does not have a genotype, the genotype of the cow's sire combined with dry matter intake information. The data have also been used to estimate the genetic correlations between the dry matter intake traits, milk production traits and weight. This means that the breeding values for milk production traits and weight are also included in the breeding value for dry matter intake.

In the calculation of breeding values for dry matter intake the following statistical model, based on research by Veerkamp (2014), is used:

$$y = EXP + HM + HY + AGE + LACTST + BREED + PERM + A + Resid$$

where:

y	:	Observation of animal;
EXP	:	Experiment, a combination of farm and management/experiment effect;
HM	:	Herd*Month of the measurement;
HY	:	Herd*Year of calving;
AGE	:	Age at calving;
LACTST	:	Lactation stage;
BREED	:	Breed percentage of the most important breed;
PERM	:	Permanent environment of animal;
A	:	Breeding value of animal;
Resid	:	Residual term of y which is not explained by the model.

▪ Parameters

Table 1 shows the heritability for dry matter intake per trait as well as the genetic standard deviation per trait. Table 2 shows the genetic correlations.

Table 1. Heritability (h^2) and genetic standard deviation (kg/day) for dry matter intake.

Trait	h^2	genetic standard deviation
Lactation 1	0,175	1,12
Lactation 2	0,185	1,25
Lactation 3+	0,197	1,37

Table 2. Genetic correlations between dry matter intake and indicator traits.

	Dry matter intake lactation 1	Dry matter intake lactation 2	Dry matter intake lactation 3+	Kg milk	Kg fat	Kg protein	Body weight
Dry matter intake lactation 1							
Dry matter intake lactation 2	0,90						
Dry matter intake lactation 3+	0,88	0,98					
Kg milk	0,57	0,57	0,57				
Kg fat	0,67	0,67	0,67	0,50			
Kg protein	0,67	0,67	0,67	0,91	0,65		
Body weight	0,53	0,53	0,53	0,05	0,15	0,16	

▪ Dry matter intake index

Indexes for dry matter intake in lactations 1, 2 and 3+ are calculated based on the breeding value for dry matter intake directly from the breeding value estimation for dry matter intake and breeding values for indicator traits from the breeding value estimation of the whole population.
If an animal has no breeding value for dry matter intake directly from the breeding value estimation for dry matter intake, the breeding value for dry matter intake is determined completely by the four indicator traits. The breeding values for dry matter intake for lactations 1, 2 and 3+ are combined in the dry matter intake index.
The dry matter intake index is a breeding value for dry matter intake across all lactations and is similar to, for example, the breeding value for milk production, where the breeding values for milk for the first three lactations have been combined into one breeding value as well.
The dry matter intake index is calculated as follows:

Dry matter intake index =   0.41 x index for lactation 1
+ 0.33 x index for lactation 2
+ 0.26 x index for lactation 3+

▪ Presentation

Breeding values for dry matter intake are shown in kg of dry matter with respect to zero. Breeding values are shown to 2 decimal places.
The dry matter intake index is calculated for all animals of a dairy breed or dual-purpose breed. Basic differences between milk goal black, milk goal red and dual-purpose are shown in Table 3.
Bulls with a daughter-based breeding value for indicator traits have a reliability for the dry matter intake index of about 60 percent.
When a bull has no daughters in milk yet, but does have a genomic breeding value for dry matter intake, the reliability is about 40 percent. Combining the genomic breeding value for dry matter intake with the breeding values for indicator traits increases the reliability of the breeding value for dry matter intake to about 57 percent.

Table 3. Basic differences for dry matter intake (kg), Z=milk goal black, R=milk goal red, D=dual purpose.

	Z→R	Z->D	R->D
Dry matter intake lactation 1	0.43	2.31	1.88
Dry matter intake lactation 2	0.48	2.55	2.07
Dry matter intake lactation 3+	0.53	2.79	2.26
Dry matter intake total	0.47	2.51	2.04

▪ Dry matter intake for maintenance

The breeding value dry matter intake indicates how many kg dry matter a cow needs per day. A cow uses feed for production, but also for maintenance and activities.
Feed saved for maintenance (FSM) can be derived from the breeding value dry matter intake.

FSM = (1000/E *(5.9 kg fat + 3.0 kg protein + 2.43 kg lactose)/301) - DMI

FSM	= breeding value feed saved for maintenance, computed as difference between dry matter intake needed for production minus total dry matter intake (kg dry matter per day)
DMI	= breeding value dry matter intake.
kg fat, kg protein and kg lactose	= breeding value 305-day production for kg fat, kg protein and kg lactose (= production day 5 to day 305). The weight factors is kVEM needed to produce 1 kg fat, protein or lactose.
E	= VEM per kg dry matter = 940 (average for a ration)

FSM indicates how much feed for maintenance can be saved by for example lower body weight, less activity of by more efficient digestion or usage of feed. A positive breeding value is preferable as feed is saved.

Saving costs for dry matter intake for maintenance can also be expressed on lactation base: multiply FSM with the standard number of lactation days and the feed cost per kg feed (0.20 euro per kg dry matter). The result is a breeding value for saved feed costs for maintenance (SFCM).

SFCM = 60.20*FSM

SFCM = saved feed costs for maintenance during a standard lactation (in euro's).

Genetic spread for FSM is 0.74 and for SFCM 45.

▪ Literature

R.F. Veerkamp, M.P.L. Calus, G. de Jong, R. van der Linde, Y. De Haas. Breeding Value for Dry Matter Intake for Dutch Bulls based on DGV for DMI and BV for Predictors. Proceedings 10th World Congress of Genetics Applied to Livestock Production, Vancouver, 2014.