

Statistical Indicators

E-20

NVI

▪ **Introduction**

Over the years, the breeding goal for dairy cattle has changed from a sole focus on production to attention for production, longevity, health traits and type. The typical cow on which the breeding goal is based, is a healthy cow with an efficient production from a healthy udder and constant fertility, which combines longevity with good feet & legs and functional type. To reach this objective, different breeding values have been developed for a large number of traits.

NVI combines information from breeding values to classify animals based on the breeding goal. The starting point in defining NVI is the breeding goal, and relations between breeding values are also taken into consideration.

NVI has replaced DPS and from February 2007 onwards sires are ranked according to this overall index. Traits in NVI have been given weight in such a way that a desired gain per trait is achieved. In the development of NVI the economic values for the three production traits have been maintained in the way they are employed in the INET. For the other traits weighing factors generating the desired gain have been calculated. For longevity (LON), fertility (FER), udder health (UDH), udder (UDD), feet & legs (F&L) and calving traits (CAL), target values have been identified to achieve the desired gains. Consolidation of fertility and improvement of the other traits constituted the starting point.

The NVI has been updated in 2012, 2018, and 2022. Since April 2018 claw health (CLW) and saved feed cost for maintenance (SFC) are included in the NVI. This NVI is used for animals which are published on the dairy goal black and the dairy goal red base. For the dual purpose breeds a separate NVI is available. The NVI for dual purpose is used for animals which breeding values are published on the dual purpose base and on the Belgium blue base. In April 2022 calf survival, the survival from day 3 tot 365 for rearing calves, is added to the Calving index

The economic weighing of the production traits can be found in the E-chapter on INET (E-9). This figure has been adopted directly into NVI.

▪ **Selection Response**

NVI is a figure on which sires are ranked and the goal is to rank the sire that produces strong daughters that come as close as possible to the breeding goal first. Besides production traits, there are functional traits in the breeding goal. Functional traits can be subdivided in longevity, health traits and type. Over the past years the importance of health has only increased. The farmer values a healthy cow, because the result is a sustainable cow with the best return and, moreover, a cow that is a pleasure to work with. Besides, consumer organizations also follow the doings of dairy farmers. Especially the health of cows is being followed critically. Type has been introduced in NVI consisting of udder and feet & legs. Most farmers agree that a cow with a functional udder and good feet & legs ensures better udder health and more pleasure in work.

NVI is based on achieving a desired selection response, i.e. which type of cow do you get. To determine this, the correlations among the traits that you want to improve are necessary. Selection on a certain trait will generally also lead to a change in another trait, the so-called correlated response. For example, selection on protein results in a decreased fertility.

Table 1 shows the genetic correlations, the heritabilities and the genetic variances which have been used to calculate the expected response. The selection response depends on the correlations which are used, because the overall index consists of several traits.

Table 1. Genetic correlations between traits, heritabilities (h^2), genetic variances (var), and number of offspring (# off) for the traits in NVI

	kg L	kg F	kg P	SFC	Lon	Udh	IFL	ICI	Clw	Dce	Mce	DV	MV	Sur	U	F&L	h^2	var	# off
kg L																	0.51	784	200
kg F	0.34																0.52	784	200
kg P	0.81	0.62															0.44	361	200
SFC	0.28	0.35	0.32														0.25	2025	20
Lon	0.38	0.16	0.40	0.51													0.14	66564	200
Udh	-0.04	0.00	-0.07	0.00	0.50												0.09	20	200
IFL	-0.27	-0.18	-0.22	-0.07	0.28	0.31											0.075	20	200
ICI	-0.36	-0.23	-0.31	-0.46	0.03	0.26	0.57										0.175	20	200
Clw	-0.02	0.24	0.18	0.09	0.40	0.10	0.27	0.33									0.175	20	40
Dce	-0.03	0.07	0.05	0.39	0.28	0.19	0.30	0.15	0.35								0.101	20	400
Mce	0.04	-0.04	0.05	-0.20	0.16	0.12	0.38	0.23	0.04	0.10							0.045	20	150
DV	0.02	0.04	0.06	0.15	0.18	0.10	0.21	0.11	0.15	0.43	0.26						0.039	20	800
MV	-0.01	0.02	0.00	0.05	0.11	0.06	0.35	0.13	0.06	0.14	0.60	-0.09					0.084	20	300
Sur	0.00	0.01	-0.01	0.11	0.19	0.16	0.18	0.03	0.10	0.14	0.12	0.25	0.22				0.011	20	500
U	-0.08	-0.07	-0.09	-0.08	0.26	0.28	0.10	0.11	0.11	0.01	0.14	-0.02	-0.06	-0.03			0.34	20	120
F&L	0.05	0.09	0.08	-0.18	0.19	0.05	0.02	0.16	0.59	0.06	0.08	0.05	0.00	0.02	0.17		0.17	20	120
BI	0.00	-0.04	0.00	-0.49	-0.13	-0.02	0.02	0.07	-0.02	-0.17	-0.04	-0.06	-0.04	-0.04	-0.06	0.06	0.23	20	120

kg L = kg lactose, kg F = kg fat, kg P = kg protein, SFC = saved feed cost for maintenance, Lon = longevity, Udh = udder health, IFL = interval first – last insemination, ICI = interval calving – first insemination, Clw = claw health, Dce = direct calving ease, Mce = maternal calving ease, DV = direct vitality, MV = maternal vitality, Sur = survival (from day 3 to 365 for rearing calves), U = udder, F&L = feet & legs, and BI = Beef index.

Table 2 shows the selection responses for sires which will be achieved after one generation for dairy. The highest response is achieved for longevity. Kg fat, kg protein, claw health and udder health also improve significantly. Saved feed cost for maintenance, fertility, the calving traits, udder, and feet & legs improve, but to a lower extent than other traits, which is in accordance with the breeding goal. The response for percentage fat with NVI is +0.03% and +0.02% for percentage protein, both on dairy goal Black base.

Table 2. Expected selection response for sires for the traits in NVI for dairy after one generation in absolute and relative units (as a percentage of the genetic standard deviation)

Trait	Unit	Absolute	Relative
Kg lactose	kg	10.5	38%
Kg fat	kg	14.2	51%
Kg protein	kg	10.5	55%
% lactose	%	-0.01	
% fat	%	+0.03	
% protein	%	+0.02	
Saved feed cost for maintenance	Euro	17.7	39%
Longevity	days	203	79%
Udder health	pnt	2.3	50%
Interval first-last insemination	pnt	1.8	39%
Interval calving-first insemination	pnt	0.9	20%
Claw health	pnt	2.5	57%
Direct calving ease	pnt	1.7	38%
Maternal calving ease	pnt	1.3	28%
Direct vitality	pnt	1.1	26%
Maternal vitality	pnt	1.0	22%
Survival	pnt	0.9	20%
Udder	pnt	1.1	25%
Feet & legs	pnt	1.4	32%

Pnt = point breeding value

Relative selection response = absolute selection response / genetic standard deviation x 100%

Table 3 shows the selection responses for sires which will be achieved after one generation for dual purpose. The highest response is achieved for longevity. Kg eiwit, uiergezondheid, uier en beenwerk verbeteren ook aanzienlijk. Kg protein, udder health, udder, and feet & legs also improve significantly. Fertility and the calving traits, but to a lower extent than other traits, which is in accordance with the breeding goal. The response for percentage fat with NVI is +0.01% and +0.01% for percentage protein, both on dual purpose base.

Table 3. Expected selection response for sires for the traits in NVI for dual purpose after one generation in absolute and relative units (as a percentage of the genetic standard deviation)

Trait	Unit	Absolute	Relative
Kg lactose	kg	8.9	32%
Kg fat	kg	10.2	36%
Kg protein	kg	8.4	44%
% lactose	%	-0.01	
% fat	%	+0.01	
% protein	%	+0.01	
Beef index	pnt	1.0	22%
Longevity	days	182	71%
Udder health	pnt	2.5	56%
Interval first-last insemination	pnt	1.7	38%
Interval calving-first insemination	pnt	1.3	29%
Direct calving ease	pnt	1.0	22%
Maternal calving ease	pnt	1.5	33%
Direct vitality	pnt	0.8	19%
Maternal vitality	pnt	0.8	17%
Survival	pnt	0.7	16%
Udder	pnt	2.0	44%
Feet & legs	pnt	2.0	45%

Pnt = point breeding value

Relative selection response = absolute selection response / genetic standard deviation * 100%

▪ Weighing Factors in NVI

The NVI formula 2022 for dairy reads as follows:

$$NVI_d = 0.37 \times Inet + 0.37 \times SFC + 0.07 \times longevity + 5.5 \times (Udh-100) + 6.5 \times (Fer-100) + 3.0 \times (Clw-100) + 2.0 \times (CAL-100) + 2.0 \times (U-100) + 2.5 \times (F\&L-100)$$

The NVI formula for dual purpose is:

$$NVI_{dp} = 0.33 \times Inet + 5.0 \times (BI-100) + 0.09 \times longevity + 5.7 \times (Udh-100) + 5.5 \times (Fer-100) + 2.0 \times (CAL-100) + 5.5 \times (U-100) + 5.5 \times (F\&L-100)$$

Where

- $Inet = 0.3 \times \text{kg lactose} + 2.1 \times \text{kg fat} + 4.1 \times \text{kg protein}$
- $Udh = 0.477 \times (SCM-100) + 0.641 \times (CM-100) + 100$
- $Fer = 0.23 \times (CR \text{ heifers}-100) + 0.23 \times (ICI-100) + 0.35 \times (IFL-100) + 0.35 \times (CR-100) + 100$

- $CAL = 0.08 \times (Dce-100) + 0.07 \times (Mce-100) + 0.50 \times (DV-100) + 0.75 \times (MV-100) + 0.14 \times (Sur-100) + 100$

The units of the NVI are points and the genetic standard deviation is 92, both for dairy and dual purpose. For udder health, fertility, udder, feet & legs, claw health, calving traits, and beef index breeding values above 100 are desirable. For inet, longevity and saved feed cost for maintenance a higher breeding value is desirable. Sires scoring high for longevity and over 100 for udder health, fertility, udder and feet & legs produce daughters that will stay longer on the farm, with less udder infections, better fertility and better udder and feet & legs. Sires with these favourable qualities will have a higher NVI. Sires that score low for these traits will have a lower NVI.

The importance of traits in NVI can be expressed in different ways:

1. Relative importance of traits in NVI based on the sum of the standard deviation of traits in NVI

The relative importance of a trait is calculated by multiplying the weighing factor with the genetic standard deviation of the trait and then divided by the total of all traits, expressed in percentage. For example, the weighing factor of udder health is 5.7 and the genetic standard deviation is 4.47. The absolute total of all weighing factors multiplied by the genetic standard deviations is 210. Therefore udder health has a relative importance in NVI of $(5.7 \times 4.47 / 210) \times 100 = 12\%$. Worldwide this is the most common way to present the weighing of traits into the breeding goal

2. Relative weights of traits in NVI based on the response

The relative weight of a trait is calculated by multiplying the weighing factor with the response of the trait and then divided by the total of all traits, expressed in percentage. For example, for longevity the weighing factor is 0.07 and the response is 203 days. The total of all weighing factors multiplied by the responses is 89 points. Therefore longevity has a relative weighing in NVI of $(0.07 \times 203 / 89) \times 100 = 16\%$. In this way it is presented how the total response is divided over the different traits

The relative importance, weighing and contribution of traits to the NVI dairy and dual purpose are shown in Table 4.

Table 4. Relative importance and weights of traits in NVI for dairy and dual purpose

	Dairy		Dual purpose	
	Importance	Weight	Importance	Weight
Inet	28%	32%	23%	22%
Saved feed cost for maintenance	9%	7%		
Beef index			11%	5%
Longevity	9%	16%	11%	18%
Udder health	13%	14%	12%	16%
Fertility	16%	12%	13%	11%
Claw health	7%	8%		
Calving index	7%	4%	6%	3%
Udder	5%	3%	12%	12%
Feet & legs	6%	4%	12%	12%

▪ **Reliability**

The reliability of NVI is calculated from the reliability of the underlying traits (INET, saved feed cost for maintenance, beef index, longevity, udder health, fertility index, claw health, calving traits, udder, and feet & legs), the variances of these traits and the weighing factors they have in NVI. The reliability of NVI represents the part of the total variance in NVI that is explained by the reliability of the breeding values of a sire for the underlying traits and the variances of these underlying traits.

▪ **Base differences**

The breeding values for kg milk, kg fat, kg protein, longevity, udder health, fertility, udder and feet & legs and calving traits are published the bases: Milk goal Black, Milk goal Red, Dual purpose and Belgian Blue. NVI can be converted to a different base by first converted the underlying traits and indexes and then compute the NVI.

▪ **Publication Requirements**

NVI of a sire is published as soon as the sire has a published breeding value for milk production traits. The requirements for publication of milk production traits can be found in chapter E-7.