User's Manual for the Program Package ECOWEIGHT (C Programs for Calculating Economic Weights in Livestock), Version 5.3.2. Part 1: Programs EWBC (Version 2.3.1) and EWDC (Version 2.2.3) for Cattle

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Preface

The program package ECOWEIGHT was written within the framework of the research projects MZE-M02-99-02, MZE0002701401 and MZE0002701404 that were supported by the Ministry of Agriculture of the Czech Republic. In the Slovak Republic, financial support was given by the Ministry of Agriculture within the framework of the research projects 2003 SP 27/028 OD 02/028 OD 02 and 2006 UO27/0910502/0910517. Travelling was funded by the Ministries of Education of the Czech Republic and Slovak Republic (Program KONTAKT, project numbers 109CZ/2002 or 198SK/2002 and MEB 080802 or SK-CZ-0007-07).

The programs for cattle were mainly written by Jochen Wolf on the basis of algorithms prepared by Marie Wolfová (both from the Institute of Animal Science in Prague Uhříněves). Parts of the programs were written by Emil Krupa from the Animal Production Research Centre Nitra.

Though only three people were engaged directly in writing the programs, a lot of colleagues has helped in different ways in preparing the algorithm for the program. Radka Zahrádková and Josef Přibyl (both Prague-Uhříněves) have given advises concerning the management systems. Josef Přibyl has furthermore made available information on the breeding value estimation and on selection programs in cattle. Jan Kica and Jozef Daňo from the Animal Production Research Centre Nitra cooperated in the fields of nutrient requirement and economics, respectively.

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More recently, the development of the program package has been influenced by the feed-back of its users who contributed with valuable comments. In this connection we would like to mention Grazia Bramante (Associazione Nazionale Allevatori Frisona Italiana, Cremona, Italy), István Komlósi (University of Debrecen, Hungary), Elli Pärna (Estonian University of Life Sciences, Tartu, Estonia), Martino Cassandro and Denis Pretto (both University of Padova, Italy) and Jarmo Juga and Pauliina Hietala (both University of Helsinki, Finland). Thanks to all of them.

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Chapter 1

Introduction

The program package ECOWEIGHT is intended for the calculation of economic values of economically important traits in livestock. At the given stage, in its fifth version, two programs for cattle and three programs for sheep are available (see Table 1.1). The two programs for cattle (EWBC and EWDC) are described in the present part of the documentation which is the first part of the manual. The second part of the program package is a stand-alone program (EWSH1) for sheep with one lambing per year [22]. The third part of the program package which is documented in two manuals is formed by the program EWSH2 for sheep [23] which is a modification of EWSH1 and by the program GFSH [21] which models gene flow in sheep. As the programs EWSH2 and GFSH are run together they are in a joint installation package. The programs for sheep have remained unchanged since version 5.1.1. of the program package and can be downloaded from this version.

Table 1.1: Survey on the program package ECOWEIGHT, version 5.3.2

Part[a]	Installation Package[b]	Program(s)	Species, remarks
01	ECOWEIGHT01_5_3_2.tgz	EWBC	beef cattle
		EWDC	dairy cattle
02	ECOWEIGHT02_5_1_1.tgz[c]	EWSH1	sheep, one lambing per year, stand-alone program
03A	ECOWEIGHT03_5_1_1.tgz[c] for both parts 03A and 03B	EWSH2	sheep, one lambing per year, used in combination with GFSH
03B		GFSH	sheep, program for gene flow, used in combination with EWSH2

[a]There is one manual for each part; its name is ECOWEIGHT[part].pdf where [part] is to be replaced by the two or three digits given in this column.
[b]Replace 'tgz' by 'zip' for Windows.
[c]Download these programs from version 5.1.1. of ECOWEIGHT.

Several pasture production systems for beef cattle without production limitation and the dairy production system which may apply terminal crossing with beef bulls are treated with in the two programs EWBC and EWDC. Economic values can be calculated for beef and dairy cattle. Pure-bred dairy production systems without terminal crossing and without production limitation or with milk and fat quota can be handled too with the program EWDC.

The inclusion of the gene-flow procedure makes it possible to calculate economic weights for maternal and direct traits and trait components as well as for different selection paths. These weights are intended to be used for the construction of selection indices to evaluate breeding animals (in beef cattle above all for bulls and bull dams). A survey of cattle production systems currently covered by the programs is given in Figure 1.1. For a first rough comparison of the economic importance of traits, the relative standardised economic values or the relative standardised economic weights for direct and maternal traits and trait components are also calculated (see Section 2.9 on page 49).

Besides this, the programs will be useful for some economic analyses in different production systems. The impact of production, management and economic circumstances on the economic efficiency of a given production system (measured as profit) can be studied.

The users of the programs EWBC and EWDC are recommended to read the papers of Wolfová et al. published 2005 in Livestock Production Science [30, 31] and 2007 in the Journal of Dairy Science [27, 28] which describe the basic theory underlying the programs and show applications. Furthermore, we recommend the paper of Wolfová and Nitter [24] where the number of discounted expressions are discussed.

At the given stage, the program EWBC is restricted to systems with calving outside the pasture season. Problems may occur when using the program on the southern hemisphere. You can overcome these problems in a simple way: add to all dates in INPUT01.TXT half a year and everything should work correctly. We are aware of this problem.

Version 5.3.2 of the program package ECOWEIGHT contains version 2.2.3 of the EWDC program and version 2.3.1 of the EWBC program.

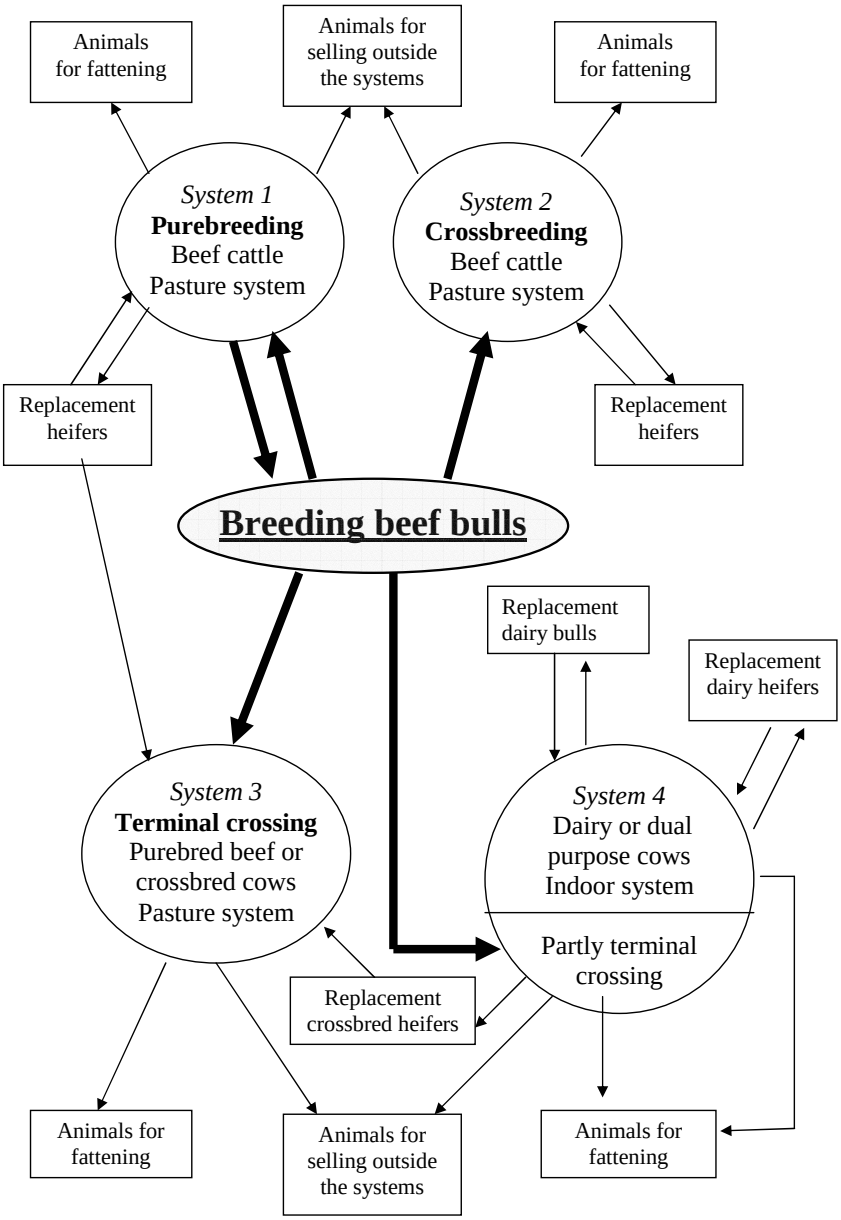

Figure 1.1: Production systems in cattle

Chapter 2

Basic description of the bio-economic model

A bio-economic model is used to describe the four main production systems in cattle (Fig. 1.1). The first three systems are beef production systems based on a cow-calf pasture system with integrated intensive (indoor) or extensive (on pasture) fattening. The fourth system is a traditional dairy production system with dairy cow herds and integrated intensive fattening. The possibility to do no fattening but to sell all weaned calves or breeding bulls and heifers outside the system (export) is also given.

The model includes both deterministic and stochastic components. Most performances of animals are simulated as herd averages, but phenotypic variation in carcass quality (described by the distribution over commercial classes), in milk production and weight of heifers at mating (described by mean and standard deviation) are included. The model is non-integer (fractions of animals are allowed) and the cow herd size is given by a fixed number of cows entering the calving season in the pasture system or by a fixed number of cows calving per year in the dairy system. Only when applying limitations to the outputs of products the number of cows is rescaled when calculating the economic weights. For the basic features of the model for beef cattle see also [30]. An application of the model to production systems with the Charolais breed in given in [31]. The main papers describing the model for dairy cattle and its application are [27] and [28].

2.1 Production systems

2.1.1 Cow-calf pasture systems (Production Systems 1 to 3)

These systems are run by the program EWBC. The management of the beef cow-calf production systems is modelled according to the typical situation in Central Europe. The reproductive cycle of cows is determined by the seasons in temperate climate. Calves are born in the winter period (in the Northern hemisphere usually from November to March) and weaned all at the same date. The length of the pasture period depends on the climatic conditions (the begin and the end of the pasture period are input parameters and can be freely chosen). In Central Europe, pasture is mostly available from the beginning of May to the end of October or November. The model can be applied also for beef cattle production systems in the tropics, if no more than two nutrition periods per year are distinguished or can be simulated (e.g. dry and wet periods will correspond to winter and summer periods in temperate climate).

All females (heifers and cows) are mated to beef bulls. The breeding season is held at constant length covering three oestrus cycles of females. One oestrus cycle is assumed to last 20 days. In the pure-bred beef herds producing breeding animals, the mating starts usually with artificial insemination by sperm of top-bulls. After the insemination period, a break in the mating is made with a length of about one weak. This is necessary for the identification of calves born after insemination. Natural mating follows on pasture. In commercial herds that produce calves for fattening, only natural mating is used in most cases. The user of the present program has the opportunity to define his own mating policy. Exclusively insemination or natural mating can be used throughout. The fractions of inseminated heifers and cows of the animals entering the mating period can be freely chosen. But the total length of the mating period should not exceed the length of three oestrus cycles to minimise the variability in the age of weaned calves. The length of the reproductive cycle is assumed to be fixed to one year. The average date of conception of all females in the herd as well as the average date at calving and at weaning is calculated on the basis of a assumed conception rate (input parameter) in each oestrus cycle within the mating period.

Weaned calves are utilised according to the replacement policy for the herd. Three possible policies are included in the model. They are designated as Production Systems 1 to 3.

- *Production System 1* includes pure-bred beef herds that produce breeding heifers for their own replacement and eventually for sale, and breeding bulls (performance-tested on station or in the field) for replacement in all connected systems.
- *Production System 2* are pure-bred or cross-bred beef herds that produce breeding heifers for their own replacement and eventually for sale but purchase sperm for artificial insemination and/or breeding bulls for natural mating (e.g. rotational crossing).
- *Production System 3* includes herds that purchase pure-bred or cross-bred replacement heifers and bulls or sperm for terminal crossing.

For all these systems, integrated fattening of excessive progeny is generally assumed, but the possibility to sale weaned calves outside the systems (for export) is also given. The sale of breeding heifers in Systems 1 or 2 is allowed only if the number of reared heifers exceed the number of heifers needed for own replacement. The number of the production system and several options connected with the production system are input parameters in the file PARA.TXT - see Section 4.1.2.

All male and female calves not sold and not needed as replacements are fattened as heifers, bulls or castrates. The proportion of fattened castrates is an input parameter. Two fattening systems are included in the model: (i) intensive fattening indoor or (ii) extensive fattening on pasture (for heifers and castrates only). Fattening is performed to a fixed optimal slaughter weight that depends on the maturity type of the animals (that means on the breed of cows and the breed of bulls used for mating). The optimal slaughter weight of cross-bred animals is calculated as the average of the optimal slaughter weight of the parental breeds.

Replacement heifers are put on the same regime as cows and are bred according to the breed type that determines the optimal weight at breeding. The weight of heifers at first breeding is assumed to follow a normal distribution whose parameters (mean and standard deviation) are input parameters in the file INPUT13.TXT (see Section 4.2.10). This procedure allows to calculate the fraction of heifers of the late maturity type (i.e. from breeds as French Charolais, which are assumed to be bred circa at an age of two years) which can be mated already at an age of approximately one year. This fraction depends on the growth rate from birth to mating.

Heifers and cows not conceived after the mating period are generally slaughtered after the finishing period on pasture. The possibility to stay to the next mating period for barren females with a high breeding value is included in the model. A maximum of three mating periods is allowed. The number of reproductive cycles per cow is an input parameter in the parameter file PARA.TXT (see Section 4.1.2). A value of approximately 15 should be a reasonable choice in most cases, as only a very small fraction of cows is assumed to have more than 15 reproductive cycles. Values lower than 4 or greater than 20 are not allowed. Each of these cycles can be described separately through inserting the appropriate input parameters for calving performance, losses of cows and calves, culling of cows due health problems or failure to conceive and the proportion of insemination[1]. In Production System 1, it is assumed that performance-tested bulls are possession of the herd owners. Therefore, costs of testing and revenues from selling breeding bulls as well as from culling negatively selected bulls are part of the herd profit in this production system.

The performance test of bulls is assumed to be of fixed length. Selected bulls are sold to the insemination stations or to the herd that uses them for natural mating. Bulls not selected are slaughtered. Selected bulls are expected to be progeny tested in the field. In the controlled herds, the progeny is weighed four times: at birth and usually at the age of about 120, 210 and 365 days. These weights and ages are used for the calculation of daily gain of calves in different growth periods in the model. The age of calves at individual weighings (growth periods) are variables in the program and can be controlled by the user. How to proceed if there are only two weighings is described in Subsection 2.6.1 on page 34.

2.1.2 Dairy production system (Production System 4)

This system is run by the program EWDC. A classical production system with dairy or dual purpose cows producing milk with integrated intensive indoor fattening is handled in the model. Calving is assumed to be equally distributed over the whole year. A rate of artificial insemination of 100% is assumed. Cows not pregnant after a fixed number of inseminations are culled at the end of the lactation. Maximally 15 lactations for a cow are allowed in the model. The number of lactations is an input parameter in the file PARAD.TXT (see Section 4.1.3 on page 61). Each of these lactations can be described separately through inserting the appropriate input parameters[2] as described for the pasture system (see Section 2.1.1).

A part of the cow herd can be inseminated with sperm of beef bulls to improve the fattening performance of progeny.

All born calves are reared together under equal conditions until reaching a given fixed age. Selling reared calves outside the system (export) is possible. Pure-bred heifers for replacement are mated at an optimal weight for the given breed, so that their age at mating depends on the growth rate in the previous period. Heifers not pregnant after a fixed number of inseminations are slaughtered after a given number of days. Cross-bred females can be finished to a fixed slaughter weight, sold outside the system (export) or transferred (sold) as replacement heifers to a joined or separate cow-calf Production System 3.

Pure-bred male calves for replacement are usually performance tested on station. Selected bulls are sold to the insemination stations and the animals not selected are slaughtered. Breeding male calves are sold to the test station at a certain age (e.g. at 3 months in Czechia). Therefore, only costs and revenues for breeding male calves

[1] If data for individual reproductive cycles are not available, insert average values (equal values) for all cycles.

[2] Again, if data for individual lactations are not available, insert average values (equal values) for all lactations.

till their selling to the test station are included in the calculation of the profit. All remaining cross-bred progeny and excessive pure-bred progeny are fattened to a fixed optimal slaughter weight that depends on the maturity type of the progeny (that means on the breed of the parents).

If pure-bred male calves intended to become breeding bulls are kept on farm also after the rearing period, special input parameters for these animals are needed (INPUT12.TXT, see on page 93).

The dairy production system can be handled independently of the beef production systems as a pure-bred system without terminal crossing and can be used to calculate economic weights for traits of dairy cattle (see first option in parameter file PARAD.TXT on page 61). In this case, all input parameters referring to crossing are ignored when reading the input files.

2.2 Structure of the cow herd

For calculating the structure of the cow herd, different categories of animals were defined. The number of reproductive cycles is an input parameter (LL) which is expected to be in the range from 4 to 15 (program EWDC) or to 20 (program EWBC). Low numbers of LL may cause problems as the cow herd might not be able to produce sufficient replacement.

Categories distinguished are related to the reproductive cycles of cows that cover the intervals between two subsequent calvings (in dairy cattle, program EWDC) or two subsequent calving seasons[3] (in beef cattle, program EWBC). A replacement female enters the herd at her calving and can stay in the herd until she is replaced or has reached the maximum of allowable calvings. Each category is characterised as a combination of two variables: *the number of the reproductive cycle* r ($r = 1, ..., LL$) and the defined *stage* s the cow is in within the given reproductive cycle ($s = 1, ..., 6$ for $r < LL$ and $s = 1, ...4$ for $r = LL$). The total number of cow categories (TT) is therefore

$$TT = 6(LL - 1) + 4 \; . \tag{2.1}$$

There are 24 categories of progeny defined (see below) and the numbering of categories starts with the progeny which takes numbers 1 to 24. Thus the appropriate cow category i ($i = 25, ..., CC$) for given r and s is:

$$i = 6(r + 3) + s \tag{2.2}$$

where $CC = TT + 24$. That means, CC is the total number of animal categories in Systems 1 to 3. In System 4, all categories of progeny may occur as pure-bred or as cross-bred categories. Therefore, the number of progeny categories is 48 and the total number of categories CT is calculated as $CT = TT + 48$. See below for the numbering of the categories. The six stages for cows are defined as given in paragraph 2.2.2.2. Just a short comment to the formula given here. This formula has no deeper sense, it is just a practical solution how to calculate i for the (fully arbitrary) system of numbering categories of animals used in the present program.

The cow herd structure in all systems was derived using Markov chains. The herd dynamics was described in terms of categories animals can belong to and probabilities of possible transitions between these categories. The procedure is similar to those described by Jalvingh et al. [9] or Reinsch and Dempfle [13]. Let $\mathbf{T}$ be the quadratic transition matrix of dimension TT with elements t_{ij} being the probability that an animal changes in a given time unit Δt from category i to category j (Δt is the length of the reproductive cycle in EWBC and EWDC).

[3] In Production Systems 1 to 3, barren cows can be kept for mating in the following year. Therefore, a cow may enter the next reproductive cycle without calving.

Assume further that $\mathbf{c}^{[t]}$ is the row vector with elements being the probability that an animal belongs to category i at time t. Then the same vector at time $t + \Delta t$, $\mathbf{c}^{[t+\Delta t]}$, is calculated as:

$$\mathbf{c}^{[t+\Delta t]} = \mathbf{c}^{[t]}\mathbf{T} \tag{2.3}$$

For $t \to \infty$, the Markov chain reaches its stationary state, that means the difference $\mathbf{c}^{[t+\Delta t]} - \mathbf{c}^{[t]}$ converges to zero. In the program, the stationary state is calculated by an iteration procedure. For more details see Wolfová et al. [30].

2.2.1 Definition of reproductive cycles

A maximal number of LL calvings per cow is assumed (LL is in the interval from 4 to 20 in Systems 1 to 3 or from 4 to 15 in System 4). On this basis, the following LL reproductive cycles are defined:

1	Cows between 1st and 2nd calving[4]
2	Cows between 2nd and 3rd calving
3	...
...	...
$LL-1$	Cows between $(LL-1)$th and LLth calving
LL	Cows from LLth calving to slaughter

2.2.2 Definition of categories of animals

2.2.2.1 Categories of progeny

There are 24 categories of pure-bred progeny which are numbered from 1 to 24. In several of the categories, subcategories are formed in Systems 1 to 3 (program EWBC) which are numbered from $CC+1$ to $CC+10$ (see below). In program EWDC (System 4), all 24 categories of progeny may occur also as cross-bred animals. The cross-bred categories are numbered from $CC+1$ to CT ($CT = CC+24$). That means if the pure-bred category has number i ($i = 1, ..., 24$), then the appropriate category of cross-bred animals has number $CC+i$. In the present version of the program, category $CC+24$ is not considered yet. In categories 4 to 24, in parentheses the periods are given for which the total revenues and total costs are calculated.

1	Still-born calves of both sexes (including aborts)
2	Calves of both sexes which died during 48 hours after birth
3	Calves of both sexes which died from 2 days of age till weaning (beef cattle) or the end of the rearing period (dairy cattle) (from birth to death)
4	Bulls which died within the fattening period (from birth to death)
5	Castrates which died in the fattening period (from birth to death)
6	Heifers which died in the fattening period (from birth to death)

[4] In beef cattle (Systems 1 to 3), these are cows between the first and the second calving season, generally between the ith and the $(i+1)$th calving season.

7 Heifers for replacement which died from weaning (beef cattle) or from the end of the rearing period (dairy cattle) to entering the cow herd (from birth to death)

8 Female calves sold at weaning (beef cattle) or at (any) given age (dairy cattle) (from birth to selling)

9 Male calves sold at weaning (beef cattle) or at (any) given age (dairy cattle) (from birth to selling)

10 Bulls transmitted or sold to the test stations and selected as breeding animals (from birth to selling)

11 Bulls transmitted or sold to the test stations and slaughtered after the test (from birth to slaughter). This category is not present in the dairy system (Production System 4).

12 Fattened heifers (from birth to slaughter)

13 Fattened heifers slaughtered due to health problems before reaching the slaughter weight (from birth to slaughter)

14 Fattened bulls (from birth to slaughter)

15 Fattened bulls slaughtered before reaching slaughter weight due to health problems (from birth to slaughter)

16 Fattened castrates slaughtered before reaching slaughter weight due to health problems (from birth to slaughter)

17 Fattened castrates (from birth to slaughter)

18 Heifers for replacement negatively selected before first mating and slaughtered (from birth to the age of female at first mating)

19 Heifers for replacement slaughtered after the mating periods because of failure to conceive (from birth to the age at mating plus time to slaughter, in Production System 3 only from purchase to slaughter)

20 Heifers purchased for herd replacement (for Production System 3 always, for Systems 1 to 2 and 4 only if not enough female animals are reared and pregnant for herd replacement; from purchase to calving)

21 Program EWBC (Systems 1 to 3): empty category (not defined), Program EWDC (System 4): reserved for veal calves in a later version of the program (not used yet in the present version)

22 Heifers for replacement conceived in the mating periods and entered the first reproductive cycle (from birth to 1st calving)

23 Breeding heifers sold to other production systems before mating (from birth to selling)

24 Pregnant heifers sold to other production systems (from birth to selling)

In Production Systems 1 to 3 (program EWBC), subcategories were defined for several categories of heifers (see on page 15). The subcategories for category 19 are:

$CC + 1$ Heifers slaughtered after the first mating period (from birth to slaughter)

$CC+2$ Heifers slaughtered after the second mating period (from birth to slaughter)

$CC+3$ Heifers slaughtered after the third mating period (from birth to slaughter)

The subcategories for category 22 are:

$CC+4$ Heifers conceived in the first mating period (from birth to calving)

$CC+5$ Heifers conceived in the second mating period (from birth to calving)

$CC+6$ Heifers conceived in the third mating period (from birth to calving)

The subcategories for category 23 are:

$CC+7$ Heifers sold before the first mating period (from birth to selling)

$CC+8$ Heifers sold before the second mating period (from birth to selling)

The subcategories for category 24 are:

$CC+9$ Pregnant heifers sold after the first mating period (from birth to selling)

$CC+10$ Pregnant heifers sold after the second mating period (from birth to selling)

2.2.2.2 Categories of cows (or developmental stages) within reproductive cycle r ($r = 1, ..., LL-1$)

$19+6r$ Cows died within the reproductive cycle (**stage 1**)

$20+6r$ Cows culled between calving and mating period due to health problems after dystocia[5] (**stage 2**)

$21+6r$ Cows culled within the reproductive cycle due to health problems other than dystocia. In System 4, this category includes cows culled for low milk production (voluntary culling).[6] (**stage 3**)

$22+6r$ Cows culled after weaning calves (or after lactation in Production System 4) because of lack of pregnancy (**stage 4**)

$23+6r$ In Production Systems 1 to 3 (program EWBC): barren cows entering the next reproductive cycle; empty category in program EWDC - Production System 4 (**stage 5**)

$24+6r$ Pregnant cows entering the next reproductive cycle (**stage 6**)

2.2.2.3 Categories of cows (or developmental stages) within reproductive cycle LL

$19+6LL$ Cows died within the reproductive cycle (**stage 1**)

$20+6LL$ Cows culled between calving and mating period due to health problems after dystocia (**stage 2**)

$21+6LL$ Cows culled within the reproductive cycle due to health problems other than dystocia. In System 4 (program EWDC), this category includes cows culled for low milk production. (**stage 3**)

$22+6LL$ Cows culled after weaning calves (or after lactation in Production System 4) (**stage 4**)

[5] For the definition of dystocia see paragraph 2.6.4.1 on page 38.

[6] This category does not contain cows culled for failure to conceive. The proportion of cows with failure to conceive is calculated in the program on the basis of the corresponding input parameters.

2.3 Lactation curve

In Production Systems 1 to 3 (program EWBC), the Wood function is used for the description of the lactation curve. Its general form looks like this [32]:

$$MP(t) = a(t+C)^b \exp(-c(t+C)) \tag{2.4}$$

where $MP(t)$ is the milk yield at day t of lactation, a, b, c are parameters and C is a constant. The value 14 was inserted for C [5].

If the parameters a, b, c are available, they can be inserted in the input file INPUT20.TXT (see Section 4.2.16 on page 85). Option 1 should be chosen in the file PARA.TXT (see Section 4.1.1.7). Otherwise option 2 should be chosen for the parameters of the lactation curve. The estimation of the parameters is then carried out as given in the subsequent section.

In System 4 (program EWDC), a further modification of the Wood function proposed by Fox et al. [5] and taking into account days in pregnancy was used:

$$MP(t) = at^b \exp(-ct) \exp(-dp) \tag{2.5}$$

where a, b, c and d are parameters and p are days in pregnancy. A simple way for a rough calculation of the parameters is given in Section 2.3.2 on the following page.

2.3.1 Calculation of the parameters of the lactation curve in program EWBC (for Production Systems 1 to 3)

The coefficients of the lactation curve are estimated according to the procedure of Fox et al. [5]. In case that there is sufficient information available, parameters directly estimated from lactation data can be inserted in the program. This option is controlled by a parameter in the input file PARA.TXT (see Section 4.1.2).

The concept of Fox et al. [5] is based on the peak milk yield (in kg/d) of a mature cow (M_{pm0}) of the given breed on the average production level. For the production level itself (PL) values between 1 and 9 are allowed, 1 representing the lowest, 5 the average and 9 the highest production level, respectively. The peak milk yield (in kg/d) for a mature cow (M_{pm}) on production level PL is then calculated as

$$M_{pm} = (0.125PL + 0.375)M_{pm0} \tag{2.6}$$

The peak milk yields (all in kg/d) for cows being two, three or four years old which are assumed to be on the first, second and third lactations, respectively, are:

$$M_{p2} = 0.6M_{pm}, \quad M_{p3} = 0.825M_{pm}, \quad M_{p4} = 0.925M_{pm}. \tag{2.7}$$

Mature cows are supposed to reach the peak milk yield after $LM_m = M_{pm} + 40$ days of lactation[7]. The appropriate values (in d) for two, three and four year old cows are:

$$LM_2 = LM_m + 10, \quad LM_3 = LM_m - 10, \quad LM_4 = LM_m - 5. \tag{2.8}$$

The coefficient a of the Wood function is for two, three, four year old and mature cows, respectively:

$$a_2 \quad = \quad (4.0 - 0.05LM_2)M_{p2}/k_2 \quad \text{with} \quad k_2 = 6$$

[7] In physics, nobody would accept such an equation. M_{pm} is in kg/d, 40 means probably 40 days and the result is in days. This is really great and possible only in agricultural sciences. But is seems to work. However only as long as you use the correct (well hidden) units.

$$\begin{aligned} a_3 &= (6.65 - 0.11LM_3M_{p3}/k_3 \quad \text{with} \quad k_3 = 8.25 \\ a_4 &= (5.85 - 0.09LM_4)M_{p4}/k_4 \quad \text{with} \quad k_4 = 9.25 \\ a_m &= (5.3 - 0.075LM_m)M_{pm}/k_m \quad \text{with} \quad k_m = 10 \end{aligned} \tag{2.9}$$

For the given values of k_2, k_3, k_4 and k_m is

$$M_{p2}/k_2 = M_{p3}/k_3 = M_{p4}/k_4 = M_{pm}/k_m = M_{pm}/10 \tag{2.10}$$

The appropriate coefficients b and c for the Wood function are:

$$\begin{aligned} b_i &= \frac{\ln M_{pi} - \ln a_i}{\ln(LM_i + 14) - 1} \\ c_i &= \frac{b_i}{LM_i + 14} \end{aligned} \tag{2.11}$$

with index i in both equations taking the values 2, 3, 4 or m.

2.3.2 Calculation of the parameters of the lactation curve in program EWDC (for Production System 4)

In the present version of the program, parameter a is calculated from the average yearly milk production per cow (YMP, in kg) as follows [5]:

$$a = (0.01YMP - 20 \times 0.454)/2.96 \tag{2.12}$$

for the first lactation and

$$a = (0.01YMP + 14 \times 0.454)/2.96 \tag{2.13}$$

for the second and subsequent lactations. The constant 0.454 not contained in the original equations of Fox et al. [5] is the conversion constant between lb and kg. Please have in mind that in the present program the unit kg is used throughout.

Parameters b, c and d may be inserted by the user in input file INPUT22.TXT (Section 4.3.6 on page 98). If no information for these parameters is available, the following values proposed by Fox et al. [5] may help:

- Parameter b: 0.08, 0.12 and 0.16 for the first, second, third and subsequent lactations, respectively.
- Parameter c: -0.002, -.004 and -0.005 for the first, second, third and subsequent lactations, respectively.
- Parameter d: -0.001 for the first lactation and -0,002 for the second and subsequent lactations.

2.4 Calculation of daily net energy and protein requirements per animal

The system for the calculation of the nutrition value of feed (metabolisable protein content in feeding rations) in our programs is based on the calculation of the "true total protein truly digestible in the small intestine" ("Protéines vraies réellement Digestibles dans l'Intestin grêle" (PDI) according to the French system [8]). The PDI content of a feeding ration has two components:

- "Protéines Digestibles dans I'Intestin d'origine Alimentaire ($PDIA$)", i.e. dietary protein undegraded in the rumen, but truly digestible in the small intestine [8].

- "Protéines Digestibles dans l'Intestin d'origine Microbienne ($PDIM$)", i.e. microbial true protein which is truly digestible in the small intestine [8]. It is PDI originating from proteins formed by the microbial population in the rumen (and the reticulum). $PDIM$ is synthesized by the rumen microbes from fermentable energy sources in the feed and amino acids or non-protein nitrogen from the breakdown of feed proteins in the rumen.

Each feed gives the rumen microbes degraded protein and usable energy, therefore $PDIM$ has two forms:

- $PDIMN$ is the microbial true protein of feed which can be synthesized from the degradable protein if the content of usable energy and other nutrition components is not limited.
- $PDIME$ is the microbial true protein of feed which can be synthesized in the rumen from the usable energy if the content of degradable protein and other nutrition components is not limited.

Because both of the situations can be true, the nutrition value of feed is characterized by two values $PDIN$ and $PDIE$:

$$\begin{aligned} PDIN &= PDIA + PDIMN \\ PDIE &= PDIA + PDIME \end{aligned} \tag{2.14}$$

The lower value is the true nutrition value of the feed, the higher value is the potential nutrition value of the feed which can be reached by a combination with a complementary feed. When calculating the nutrition value of a special feeding ration, the values of $PDIN$ and $PDIE$ shoud be summed up separately over the feed ration components.

In the Czech Republic, for example, two different recommendations for the calculation of the PDI content in the feeding rations exists. According to the older recommandation [18], the minimum from the two values $PDIN$ and $PDIE$ calculated for the given feeding ration should be selected as true nutrition value PDI. The newer concept [12] prefers the direct use of $PDIN$ as PDI, because feeding rations in the Czech Republic have generally sufficient (or too much) energy but an insufficient protein content. In our examples for feeding rations (see Subsection 2.4.9), the values of $PDIN$ are used for protein content (in g PDI).

In all equations, net energy (NE) and protein (PDI) requirements are calculated in MJ NE/day and in g/day, respectively.

2.4.1 Calves from birth to 3 months of age (energy and protein requirements for growth and maintenance)

The average daily net energy (NE) and protein (PDI) requirements are calculated as follows [16]:

$$\begin{aligned} NE &= -2.67 + 0.4184 W^{0.75} + 5.6854 ADG + 1.7526 ADG^2 \\ PDI &= -8.88 + 3.2527 W^{0.75} + 274.4842 ADG - 16.5273 ADG^2 \end{aligned} \tag{2.15}$$

where W is weight in kg at the given day and ADG is average daily gain for the given period in kg/day.

2.4.2 Calves from 3 months of age to weaning (beef cattle) or to the end of the rearing period (dairy cattle): Growth and maintenance

The following equations for energy and protein requirements were proposed by Petrikovič and Sommer [12] (the first equation for NE refers to beef calves, the

second equation for NE is valid for dairy calves):

$$\begin{aligned} NE &= 0.57W^{0.75}(0.530 + 0.400ADG) \\ NE &= 0.58W^{0.75}(0.550 + 0.445ADG) \\ PDI &= 3.25W^{0.75} + (220.5 + 0.976W^{0.75})ADG \end{aligned} \tag{2.16}$$

2.4.3 Fattened heifers (growth and maintenance)

Equations according to Sommer et al. [16] (the first equation for NE refers to heifers of the beef type, the second equation for NE is valid for heifers of the dairy type):

$$\begin{aligned} NE &= k_{he}\left(0.348k_tW^{0.75} + 0.004W^{1.3} + 5.584ADG^2\right) \\ NE &= k_{he}\left(0.35k_tW^{0.75} + 0.0022W^{1.4} + 7.254ADG^{1.7}\right) \\ PDI &= k_{hp}\left(3.25W^{0.75} + 0.147W + 216.3ADG - 5\right) \end{aligned} \tag{2.17}$$

where k_{he} is an adjustment factor for energy requirement of heifers referring to their maturity type, k_t is an adjustment factor for housing technology and k_{hp} is an adjustment factor for protein requirement of heifers referring to their maturity type.

2.4.4 Fattened bulls (growth and maintenance)

All equations were derived by Petrikovič and Sommer [12].
Equations for bulls of dairy type:

$$\begin{aligned} NE &= (0.34k_t + 0.25ADG)W^{0.75} \\ PDI &= 3.25W^{0.75} + (220 + 0.70W^{0.75})ADG \end{aligned} \tag{2.18}$$

Equations for bulls of dual purpose type:

$$\begin{aligned} NE &= 0.34k_tW^{0.75} + (2.5 + 0.16W^{0.75})ADG \\ PDI &= 3.25W^{0.75} + (220 + 0.85W^{0.75})ADG \end{aligned} \tag{2.19}$$

Equations for bulls of beef type:

$$\begin{aligned} NE &= 0.34k_tW^{0.75} + (3.0 + 0.13W^{0.75})ADG \\ PDI &= 3.25W^{0.75} + (220 + 0.975W^{0.75})ADG \end{aligned} \tag{2.20}$$

2.4.5 Fattened castrates (growth and maintenance)

Equations according to Petrikovič and Sommer [12]:

$$\begin{aligned} NE &= k_{ce}W^{0.75}(0.34k_t + 0.275ADG) \\ PDI &= k_{cp}\left(3.25W^{0.75} + (220 + 1.050W^{0.75})ADG\right) \end{aligned} \tag{2.21}$$

where k_{ce} and k_{cp} are adjustment factors for energy requirement and protein requirement, respectively, of castrates referring to their maturity type.

2.4.6 Replacement heifers from weaning (beef cattle) or from the end of the rearing period (dairy cattle) to calving (growth, maintenance and pregnancy)

Equations according to Petrikovič and Sommer [12]:

Heifers of dairy type:

$$\begin{aligned} NE &= 0.587W^{0.75}(0.53k_t + 0.445ADG) + NE_p \\ PDI &= 3.25W^{0.75} + (220.5 + 0.976W^{0.75})ADG + PDI_p \end{aligned} \tag{2.22}$$

where NE_p and PDI_p are the additional daily net energy and protein requirements, respectively, caused by pregnancy. They are calculated as in Section 2.4.8.

Heifers of dual purpose type:

$$\begin{aligned} NE &= 0.580W^{0.75}(0.53k_t + 0.415ADG) + NE_p \\ PDI &= 3.25W^{0.75} + (220.5 + 0.976W^{0.75})ADG + PDI_p \end{aligned} \tag{2.23}$$

Heifers of beef type:

$$\begin{aligned} NE &= 0.570W^{0.75}(0.53k_t + 0.400ADG) + NE_p \\ PDI &= 3.25W^{0.75} + (220.5 + 0.976W^{0.75})ADG + PDI_p \end{aligned} \tag{2.24}$$

2.4.7 Replacement breeding bulls from weaning (beef cattle) or from the end of the rearing period (dairy cattle) to mature weight (growth and maintenance)

The same equations as for fattened bulls were used until bulls reached mature weight (see Section 2.4.4). The net energy and protein requirements for maintenance after reaching mature body weight were calculated as follows [16]:

$$\begin{aligned} NE &= 14.35 + 0.044W \\ PDI &= 153 + 0.511W \end{aligned} \tag{2.25}$$

2.4.8 Cows (growth, maintenance, pregnancy and lactation)

The overall daily net energy and digestible protein requirements for cows were assumed to be:

$$\begin{aligned} NE &= k_t k_b NE_m + NE_g + NE_l + NE_p \\ PDI &= PDI_m + PDI_g + PDI_l + PDI_p \end{aligned} \tag{2.26}$$

where k_b is an adjustment factor for breed, k_t is an adjustment factor for housing technology (see [5] for adjustment factors), NE_m, NE_g, NE_l and NE_p are the daily net energy requirements for maintenance, growth, lactation and pregnancy, respectively, PDI_m, PDI_g, PDI_l and PDI_p are the appropriate terms for digestible protein requirements.

The energy and protein requirements for maintenance and growth were calculated as [18]:

$$\begin{aligned} NE_m &= 0.293W^{0.75} \\ PDI_m &= 3.25W^{0.75} \\ NE_g &= 22ADG \\ PDI_g &= 230ADG \end{aligned} \tag{2.27}$$

The energy and protein requirements for lactation were estimated from the daily milk production adjusted for fat and protein content [12]:

$$\begin{aligned} NE_l &= MP(0.95 + 0.37fat + 0.21prot + 0.07) \\ PDI_l &= MP(6.7 + 1.05fat + 11.5prot) \end{aligned} \tag{2.28}$$

where MP is the daily milk production with the milk fat percentage fat and milk protein percentage $prot$. The calculation of the daily milk production is treated with in Section 2.3.

The energy and protein requirements for pregnancy were calculated as follows [17]:

$$\begin{aligned} NE_p &= 0.0024116BW(0.4504 - 0.000766d_p)\mathrm{e}^{(0.03233-0.0000275d_p)d_p} \quad (2.29) \\ PDI_p &= 1.64 \times 6.25BW(0.001669 - 0.00000211d_p)\mathrm{e}^{(0.0278-0.0000176d_p)d_p} \end{aligned}$$

where BW is the birth weight of calves in kg and d_p is the duration of pregnancy in days. The coefficient 1.64 transforms the net protein values originally calculated in [17] into PDI values.

2.4.9 Examples for feed rations and their energy and protein content

Several examples for feed rations and their energy and protein content (for the Charolais breed) are given in Tables 2.1 to 2.8 (see pages 26 to 29). The numbers printed in italics are input parameters for the program EWBC.

Table 2.1: Example for energy and protein content in feed rations for cows

	Feed ration		Price	Dry matter	Net energy	Protein
	Component	Proportion	EUR/kg	kg/kg	MJ/kg DM	g PDI/kg DM
Summer	Pasture	1.00	*0.01*	*0.20*	*6.15*	*95.1*
Winter	Lucerne hay	0.30	0.028	0.85	5.07	112.4
	Corn silage	0.58	0.02	0.24	6.13	58.9
	Mashed barley	0.12	0.124	0.91	8.25	92.4
	Total	1.00	*0.0348*	*0.50*	*6.06*	*93.2*

DM: dry matter, EUR: Euro

Table 2.2: Example for energy and protein content in feed rations for calves till weaning if milk yield is insufficient

	Feed ration		Price	Dry matter	Net energy	Protein
	Component	Proportion	EUR/kg	kg/kg	MJ/kg DM	g PDI/kg DM
Summer	Pasture	0.67	0.01	0.20	6.15	95.1
	Mashed oats	0.33	0.10	0.88	7.45	86.2
	Total	1.00	*0.0397*	*0. 412*	*7.04*	*89.0*
Winter	Mashed oats	1.00	*0.10*	*0.352*	*7.45*	*86.2*

Table 2.3: Example for energy and protein content in feed rations for heifers from weaning to calving

	Feed ration		Price	Dry matter	Net energy	Protein
	Component	Proportion	EUR/kg	kg/kg	MJ/kg DM	g PDI/kg DM
Summer	Pasture	1.00	*0.01*	*0.20*	*6.15*	*95.1*
Winter	Lucerne hay	0.18	0.028	0.85	5.07	112.4
	Corn silage	0.78	0.02	0.24	6.13	58.9
	Mashed barley	0.04	0.124	0.91	8.25	92.4
	Total	1.00	*0.0256*	*0.38*	*5.91*	*83.8*

Table 2.4: Example for energy and protein content in feed rations for breeding bulls for natural mating

	Feed ration		Price	Dry matter	Net energy	Protein
	Component	Proportion	EUR/kg	kg/kg	MJ/kg DM	g PDI/kg DM
Summer	Pasture	1.00	*0.01*	*0.20*	*6.15*	*95.1*
Winter	Lucerne hay	0.10	0.028	0.85	5.07	112.4
	Mashed oats	0.14	0.10	0.88	7.45	86.2
	Corn silage	0.73	0.02	0.24	6.13	58.9
	Wheat straw	0.03	0.008	0.87	3.15	24.3
	Total	1.00	*0.0316*	*0.41*	*6.12*	*74.5*

Table 2.5: Example for energy and protein content in feed rations for heifers and castrates in extensive fattening

	Feed ration		Price	Dry matter	Net energy	Protein
	Component	Proportion	EUR/kg	kg/kg	MJ/kg DM	g PDI/kg DM
Summer	Pasture	1.00	*0.01*	*0.20*	*6.15*	*95.1*
Winter after weaning	Lucerne hay	0.18	0.028	0.85	5.07	112.4
	Corn silage	0.78	0.02	0.24	6.13	58.9
	Mashed barley	0.04	0.124	0.91	8.25	92.4
	Total	1.00	*0.0256*	*0.38*	*5.91*	*83.8*
Intensive feeding after pasture	Corn silage	0.58	0.02	0.24	6.13	58.9
	Pulses-grain haylage	0.16	0.028	0.47	5.02	79.0
	Extracted soy cake	0.07	0.48	0.88	8.38	352.8
	Winter barley	0.18	0.124	0.88	8.30	77.8
	Dicalcium phosphate	0.01	0.52	1.00	0.00	0.0
	Total	1.00	*0.076*	*0.50*	*6.70*	*114.4*

Table 2.6: Example for energy and protein content in feed rations for bulls and castrates in intensive fattening

Feed ration		Price	Dry matter	Net energy	Protein
Component	Proportion	EUR/kg	kg/kg	MJ/kg DM	g PDI/kg DM
Corn silage	0.56	0.02	0.24	6.13	58.9
Pulses-grain haylage	0.15	0.028	0.47	5.02	79.0
Extracted soy cake	0.07	0.48	0.88	8.38	352.8
Winter barley	0.22	0.124	0.88	8.30	77.8
Dicalcium phosphate	0.01	0.52	1.00	0.00	0.00
Total	1.00	*0.0796*	*0.47*	*7.08*	*107.9*

Table 2.7: Example for energy and protein content in feed rations for heifers in intensive fattening

Feed ration		Price	Dry matter	Net energy	Protein
Component	Proportion	EUR/kg	kg/kg	MJ/kg DM	g PDI/kg DM
Corn silage	0.58	0.02	0.24	6.13	58.9
Lucerne haylage	0.16	0.028	0.85	5.07	112.4
Winter barley	0.18	0.124	0.88	8.30	77.8
Extracted soy cake	0.07	0.48	0.88	8.38	352.8
Dicalcium phosphate	0.01	0.52	1.00	0.00	0.00
Total	1.00	*0.076*	*0.50*	*6.70*	*114.4*

2.5 Revenues and costs of the integrated production systems

2.5.1 Revenues

The revenues in all integrated cattle production systems come from the sale of weaned or reared calves, pregnant or barren breeding heifers, selected breeding bulls (only in Production Systems 1 and 4), slaughtered heifers, bulls, castrates, culled breeding heifers and cows, sale of manure and governmental subsidies. The revenues from milk and sale of cross-bred breeding heifers are to be added in the dairy system. Revenues from slaughtered animals are calculated from the live weight at slaughter, dressing percentage and average price received per kg of carcass weight.

2.5.1.1 Calculation of the price per kg carcass weight

The average price per kg of carcass depends on the distribution of carcasses over the commercial carcass grading classes according to fleshiness and fat covering. Assuming n_{FL} classes for fleshiness and n_{FC} classes for fat covering, a $n_{FL} \times n_{FC}$ matrix $\mathbf{P}_i$ is constructed for each category i of animals whose elements P_{ijk} are the frequencies of animals belonging to the jth class of fleshiness and kth class of fat covering. The price for the combination of fleshiness class j and fat covering class k is calculated as the product from a base price and a coefficient for this combination of classes. In the default set of parameters for the program, the SEUROP grading system with 6 classes for fleshiness (originally S, E, U, R, O, P, in the program the figures 1 to 6 are used instead) and 5 classes for fat covering (1 to 5) is used. It makes sense to use as base price the price for the best combination of classes which might be S1 in the SEUROP system. But the base price may be the price for any combination of classes.

The $n_{FL} \times n_{FC}$ matrix of these coefficients for multiplying the base price with is called $\mathbf{K}_i$ with the elements k_{ijk}. The coefficient for the combination of classes

Table 2.8: Example for energy and protein content in feed rations for breeding bulls on test station

Feed ration		Price	Dry matter	Net energy	Protein
Component	Proportion	EUR/kg	kg/kg	MJ/kg DM	g PDI/kg DM
Corn silage	0.56	0.02	0.24	*6.13*	58.9
Pulses-grain haylage	0.14	0.028	0.47	5.02	79.0
Extracted soy cake	0.07	0.48	0.88	8.38	352.8
Winter barley	0.22	0.124	0.88	8.30	77.8
Dicalcium phosphate	0.01	0.52	1.00	0.00	0.0
Total	1.00	*0.0796*	*0.47*	*7.08*	*107.9*

$j' \times k'$with base price ($k_{ij'k'}$) must be naturally set to 1. If the base price is chosen as the maximal price, all remaining elements of the matrix will be not greater than 1. The average price per kg carcass for category i of fattened animals and culled breeding heifers and cows (pr_i) is then calculated as

$$pr_i = prbase_i \sum_{j=1}^{n_{FL}} \sum_{k=1}^{n_{FC}} k_{ijk} P_{ijk} \tag{2.30}$$

where $prbase_i$ is the base price (see also [30]).

In the programs, animals culled before reaching the demanded slaughter weight can be given a lower price per kg carcass and a lower value for dressing percentage than animals reaching the demanded slaughter weight. For this purpose, several coefficients are available in input files INPUT03.TXT, INPUT08.TXT, INPUT09.TXT and INPUT10.TXT for program EWBC and in input files INPUT11.TXT and INPUT23.TXT for program EWDC.

2.5.1.2 Calculation of the milk price

The milk price depends on the pricing system used. There is a great variety in pricing systems for milk. Usually, the price for milk that is payed farmers by dairies depends on milk quality and on milk composition. The program allows accounting the average milk price for somatic cell count, milk fat and milk protein content and two milk coagulation properties (rennet coagulation time and curd firmness). Five different options are taken into account (see Paragraph 4.1.1.15 for details). Choose among these options that one which is adequate for your system. If you will not find an appropriate option describing the situation in your production system, contact the authors of the program. In the following sections, the calculation of milk price for each of the five options is described in some detail.

Comment to the calculation of the milk price

The measurements of milk quality and milk components are taken daily in the dairies from the milk bulk tank and not from individual cows. Therefore, for the calculation of milk price, the standard deviations for bulk tank measurements and not for measurements of individual cows should be used to avoid an over- or underestimation of economic values for the milk quality measurements (fat and protein content, SCC, rennet coagulation time and curd firmness). If the data from dairies are not available, the standard deviations can be calculated from test-day herd averages. See also [14].

2.5.1.2.1 Option 1 for *milkprice*: the milk price does neither depend on the somatic cell count nor on the following four factors: protein content,

fat content, rennet coagulation time and curd firmness The milk price is an input parameter. Prepare input file INPUT28.TXT as shown in Example 1 for INPUT28.TXT on page 104. The number of milk quality classes according to somatic cell count ($nSCC$) is automatically set to 1 in the program.

2.5.1.2.2 Option 2 for *milkprice*: The milk price ($prmilk$) depends (only) on somatic cell count. Several milk quality classes for somatic cell count are assumed. Insert a number >1 for the number of these classes ($nSCC$) in the file INPUT28.TXT. In the same input file, insert $nSCC$ numbers in the vector of basic prices per kg milk in quality class i ($prSCC[i]$) and $nSCC-1$ numbers in the vector of upper limits for the somatic cell count in the individual milk quality classes. Further input parameters are the mean somatic cell score and the phenotypic standard deviation of the somatic cell score. Assuming a normal distribution for the somatic cell score, the proportions of sold milk in quality class i ($pSCC[i]$) are calculated. Then, the milk price is calculated as follows:

$$prmilk = \sum_{i=0}^{nSCC-1} pSCC[i] \cdot prSCC[i] \tag{2.31}$$

Examples 6 and 7 for INPUT28.TXT (see paragraphs 4.3.11.6 and 4.3.11.7) refer to option 2.

2.5.1.2.3 Option 3 for *milkprice*: The milk price depends (only) on one to four of the following factors: fat content, protein content, rennet coagulation time and curd firmness. Assume that there are $nfat$ and/or $nprot$ threshold values for fat and/or protein content and $nRCT$ and/or $na30$ threshold values for rennet coagulation time and/or curd firmness (a special case is a zero number of threshold values). That means there will be $nfat$+1, $nprot+1$, $nRCT$+1, $na30+1$ classes (intervals) for fat content, protein content, rennet coagulation time and curd firmness, respectively. Within each class (interval), a linear regression on the given factor is assumed which is described by three parameters: a constant (b_0), the regression coefficient (b_1) and a reference value (x_r) for the appropriate factor (fat content, protein content, rennet coagulation time or curd firmness) for which the base milk price is payed:

$$y = b_0 + b_1(x - x_r) \tag{2.32}$$

where y is the value to be added to the base milk price ($prmilkb$), the first input parameter in file INPUT28.TXT, for the given value of x, x being milk fat content, milk protein content, rennet coagulation time or curd firmness. See Section 4.3.11 for some more details and for the way how to describe a concrete situation in the input file INPUT28.TXT.

The milk price is calculated as

$$prmilk = prmilkb + \sum_{i=1}^{nfat+1} F_i + \sum_{i=1}^{nprot+1} P_i + \sum_{i=1}^{nRCT+1} R_i + \sum_{i=1}^{na30+1} A_i \tag{2.33}$$

where $prmilkb$ is the base milk price, F_i is the value from the ith class of fat content which is added to the base milk price, P_i is the appropriate value from the ith class of protein content, R_i is the appropriate value from the ith class of rennet coagulation time and A_i is the appropriate value from the ith class of curd firmness. For calculating these values, it is assumed that all four factors are normally distributed with a given mean and standard deviation (input parameters). From this normal distribution, the proportion of the individual classes can be calculated.

For the special case that $b_0 \neq 0$ and $b_1 = 0$, F_i, P_i, R_i and A_i are simply calculated by multiplying the proportion of values of the appropriate factor in class i by the constant b_0. If the regression coefficient b_1 is different from zero, the given interval is subdivided into 500 intervals of equal width. For each interval, the proportion of values of the appropriate factor being within is calculated and multiplied by the mean x-value of the interval and the regression coefficient b_1. F_i, P_i, R_i and A_i are then calculated as the sum of these 500 values.

2.5.1.2.4 Option 4 for *milkprice*: The milk price (*prmilk*) depends both on somatic cell count (SCC) and on one to four of the following factors: fat content, protein content, rennet coagulation time and curd firmness. The base prices for quality classes according to SCC are set first and then these prices are corrected for further factors. First, a preliminary milk price is calculated according to equation (2.31). The further correction on fat content, protein content, rennet coagualation time and curd firmness is carried out using equation (2.33) where the preliminary milk price calculated before is inserted for the variable *prmilkb*.

2.5.1.2.5 Option 5 for *milkprice*: The milk price (*prmilk*) depends both on somatic cell count (SCC) and on one to four of the following factors: fat content, protein content, rennet coagulation time and curd firmness. The base price for milk (milk carrier or milk with given fat and/or protein content and/or milk coagulation properties) is determined first. Then this price is corrected for the real values of at least one of the following four factors: protein content, fat content, rennet coagulation time and curd firmness. At the last step, a further correction of the price for milk quality classes based on SCC is carried out. First, a base milk price (*prmilkb*, first input parameter in INPUT28.TXT) must be given. Then equation (2.33) is used to correct the price for one to four of the following factors: fat content, protein content, rennet coagulation time and curd firmness. Let us write $prmilkfp$ for the resulting (preliminary) milk price. For each quality class i of milk according to somatic cell count, a multiplicative ($facSCC[i]$) and an additive ($prSCC[i]$) price adjustment factor are read from INPUT28.TXT. Then the final milk price is:

$$prmilk = \sum_{i=0}^{nSCC-1} pSCC[i]\,(prmilkfp \cdot facSCC[i] + prSCC[i]) \tag{2.34}$$

where $pSCC[i]$ has the same meaning as in (2.31). Several of the multiplicative ($facSCC[i]$) and additive ($prSCC[i]$) price adjustment factors may take a value of zero. No change of the milk price means that the multiplicative adjustment factor is 1 and the additive factor zero. If you want to add or subtract a constant to or from the milk price in the given milk quality class, the multiplicative adjustment factor is 1 and the additive factor is a positive or a negative constant, respectively. If you want the final milk price to be 30% of the preliminary price, set the multiplicative constant to 0.3 and the additive constant to 0. If you desire to set the milk price to a constant independent of the preliminary price, set the multiplicative factor to zero and the additive factor to the constant. See also examples for input file INPUT28.TXT in Section 4.3.11 on page 102.

2.5.2 Costs

Costs are related to feeding of animals, housing, veterinary treatment, dystocia, other costs and fixed costs. The *cost for feeding* are calculated on the basis of daily

net energy and protein requirement of animals and from the price for feed with given dry matter, net energy and protein content (see Section 2.4). Daily net energy and protein requirement cover requirements for maintenance, growth, lactation and pregnancy. Feeding for suckler cows with calves, breeding heifers, bulls and for extensively fattened young animals is assumed to be different between the summer and winter periods. Basically, it is expected that energy and protein requirements are supplied entirely by pasture during summer, but the summer and winter feed rations as well as the feed rations in intensive fattening and the appropriate losses of feed can be set by the user of the program.

An example of feed rations for pure-bred Charolais is given in Tables 2.1-2.8. The values printed in italics are the input parameters that were used as default values for the program. The feeding costs include also costs for water and minerals. The costs for feed from pasture should be estimated only on the basis of direct costs per ha of pasture per year (fertilisation, labour, machinery, repairing costs for folding).

When calculating feed costs, two different feeding periods according to the season (summer and winter or dry and wet periods) can be distinguished in beef cattle (program EWBC). In the dairy system (program EWDC), two feeding periods for rearing calves are distinguished. The feed ration for the first feeding period is usually based on milk mainly.

If phase feeding with different feed rations will be applied for an animal category (e.g. for bulls in fattening) the structure of the average feed ration should be calculated on the basis of the total amount of the different feed components in the whole period for which the feeding cost should be calculated.

Depreciation costs for buildings are included in fixed costs per cow and depend on the size of the cow herd. The *costs for housing* are the difference between the costs for straw and the revenues from manure and are expressed per animal and day. In the cow herds on pasture and in extensive fattening, they are calculated only for the winter period, whereas they are taken into account throughout in intensive fattening. The amount of straw needed depends on the housing technology. As the price per kg manure is usually higher than for straw, these costs have generally a negative sign.

The *costs for veterinary treatment* include veterinary fees and drugs and are expressed per animal of the given category. Therefore, they are not expected to change with a small alteration in the length of the fattening or rearing period. Dystocia costs are calculated per calving in the herd. They depend on the proportion of calvings in each calving score and on veterinary and labour costs connected with these scores.[8]

Other costs are expressed per animal of the given category and include costs for removing and rendering dead animals (for categories that died) or breeding costs for heifers and cows. Breeding costs are costs for insemination and natural mating. Costs for natural mating per female are calculated on the basis of the price for breeding bulls, costs for keeping this bulls in the herd and from the number of females per bull and per reproductive cycle. The breeding costs are lowered by the revenues from culled breeding bulls.

Fixed costs are all remaining costs in the system: costs for labour, energy, insurance, interest of investment etc. They depend mainly on the farm size and housing technology and are expressed per animal of the given category and per day. They are treated as variable costs in respect to the length of the fattening or rearing period. For example, they change with changing growth rates of animals in fattening or in the rearing period of heifers. That means that an alternative use of saved production factors (e.g. fattening places) is expected considering the production in

[8] See Subsection 2.6.4.1 for calving score.

long-range terms.

Culling animals of a given category for health problems and death of animals is expected to be equally distributed over the period for which the costs are calculated. Therefore, for simplicity, it is assumed that these animals are culled or died on average in the middle of the period and all costs of these categories of animals refer to this date.

In program EWDC, a further cost parameter (Variable costs for milk when increasing the milk yield above average) is included in input file INPUT11.TXT. These costs are taken into account only when calculating the economic value for milk yield.

2.5.3 Economic efficiency of the production systems (profit)

The economic efficiency of all production systems is expressed as profit per cow entering a reproductive cycle and per year. Profit is calculated as the difference between the total revenues and total costs obtained per cow and her progeny born per year.

The possibility to take into account the time delay between the birth of progeny of a cow and the occurrence of revenues and costs from these progeny is given in the model. This possibility is used if a value different from zero is put for the input parameter *discount rate* in the input file INPUT03.TXT of program EWBC (Systems 1 to 3, see Section 4.2.3) or the input file INPUT11.TXT of program EWDC (System 4, see Section 4.3.2). In this case, all revenues and costs occurring in the herd within a year and in the whole life of progeny born in the herd during the year are discounted to the birth of the progeny by the given discount rate. The discount rate should be a combination of the average yearly interest and inflation.

In mathematical terms, the total profit (TP) is calculated as

$$TP = \mathbf{rev}'\mathbf{NDE}^{[\mathbf{rev}]} - \mathbf{cost}'\mathbf{NDE}^{[\mathbf{cost}]} + Subsidies \tag{2.35}$$

with

$$\mathbf{NDE}^{[\mathbf{rev}]} = \mathbf{l} \odot \mathbf{q}^{[\mathbf{rev}]}, \qquad \mathbf{NDE}^{[\mathbf{cost}]} = \mathbf{l} \odot \mathbf{q}^{[\mathbf{cost}]} \tag{2.36}$$

the elements of vectors $\mathbf{q}^{[\mathbf{rev}]}$ and $\mathbf{q}^{[\mathbf{cost}]}$ being

$$q_i^{[rev]} = (1+u)^{-t_i^{[rev]}}, \quad q_i^{[cost]} = (1+u)^{-t_i^{[cost]}} \tag{2.37}$$

where **rev** and **cost** are column vectors of revenues and costs, respectively, per animal, the elements of which are rev_i and $cost_i$, i being the category of animals ($i = 1, ..., CC$ in program EWBC and $i = 1, ..., CT$ for program EWDC), the apostrophe stands for the transpose (i.e. $\mathbf{rev}'$ and $\mathbf{cost}'$ are the appropriate row vectors), $\mathbf{NDE}^{[\mathbf{rev}]}$ and $\mathbf{NDE}^{[\mathbf{cost}]}$ are the column vectors of the number of discounted expressions connected with revenues and costs, respectively, the elements of which are $NDE_i^{[rev]}$ and $NDE_i^{[cost]}$, $\mathbf{l}$ is a column vector which elements l_i are the numbers of animals in category i per cow and year in the stationary state of the production system, $\mathbf{q}^{[\mathbf{rev}]}$ and $\mathbf{q}^{[\mathbf{cost}]}$ are the column vectors of discounting coefficients for revenues and costs, respectively, with elements $q_i^{[rev]}$ and $q_i^{[cost]}$, u is the annual discount rate, $t_i^{[rev]}$ and $t_i^{[cost]}$ are the intervals between calving and the time when revenues and costs occur in category i, and $\odot$ is the Hadamard product (element-wise product) of the two vectors. The *Subsidies* are per cow and year.

Using this approach, all revenues and costs occurring in the cow herd during the year and in the life of progeny born in this herd per year are discounted to the date of calving (birth of progeny). The life of progeny covers the time from birth to slaughter, to death, to selling or to 1st calving of heifers. The time delay between birth and the occurrence of revenues and costs can be neglected when setting the

discount rate zero. In this case the NDEs reduce to the number of animals per cow and year in the given categories.

The profitability including subsidies ($Profitabd$) is calculated as

$$Profitabd = 100 \times TP/TC \tag{2.38}$$

where TP is the total profit and TC is the total cost. In addition, the profitability without subsidies ($Profitab$) is calculated as

$$Profitab = 100(TP - Subsidies)/TC \tag{2.39}$$

The subsidies are per cow and year. The subsidies in the programs are no function of the evaluated traits. Therefore, the value of subsidies does not influence the economic values of traits.

2.6 Traits the economic values are calculated for

Generally, three groups of traits are of interest in cattle: growth traits, carcass traits and functional traits (reproduction and health). For dairy cattle, milk production traits are to be attached. If there is crossing in the dairy cattle herds, the economic value for a trait is calculated separately for pure-bred and cross-bred animals.

2.6.1 Growth traits

Growth is assumed to be the same trait in both sexes. Intra-breed differences between sexes are assumed to be expressed by constant factors. Therefore, for the calculation of economic values for growth, a reference growth trait can be defined. Live weights or growth rates of females which are specific for the breeding type (pure-bred or cross-bred), are mostly used as reference growth traits.

When calculating the economic weights for a growth trait, the average values of the appropriate trait is changed in both sexes by multiplying with the same factor (1.005: for increasing the trait, 0.995: for decreasing the trait, which means a 0.5% change in mean of trait in both directions). Than, the economic values are expressed per unit of the reference trait and per cow and year, but they also include the economic effect of the changes in all related growth traits in other sexes.

To allow for changing the growth curve of cattle by selection using different weightings for the individual parts of the growth curve, each part of the growth curve was evaluated separately keeping the remaining parts of the growth curve unchanged. Each of the evaluated part of the growth curve was approximated with a linear function.

In beef cattle (program EWBC), three weighings during the growth of calves are assumed (at about 120, 210 and 365 days of age). If only two weighings are available, the following trick can help to make the program work. Set the input parameters in INPUT06.TXT (see Section 4.2.6) as follows:

- Insert your first known age and weight of male and female calves (e.g. age and weight at weaning) as values for the first weighing.
- Insert the values for your second weighing as input parameters for the third weighing.
- Construct a fictive second weighing very close to the first weighing. Use as input parameters age at first weighing + 1 and weight as first weighing + gain in weight for one day calculated from the average daily gain from birth to first weighing.

- Ignore the economic weight for daily gain from 1st to 2nd weighing and for weight gain of calves from 1st to 2nd weighing in the results.
- The economic weight for daily gain from your 1st to 2nd weighing is printed as the economic weight for daily gain from 2nd to 3rd weighing. The economic weight for weight gain of calves from your 1st to 2nd weighing is printed as the economic weight for weight gain of calves from 2nd to 3rd weighing.

A change in the level of any growth trait is assumed to cause a change in the energy and protein requirement of animals, because no economic values are calculated both for feed intake and for feed conversion. Therefore, feed costs are taken into account when calculating the economic values of growth traits. The efficient usage of feed is described by the residual dry matter intake (see Subsection 2.6.3).

2.6.1.1 Mature weight

In cows, mature weight is defined as average weight after the 3rd calving in both programs (EWBC and EWDC). An increase in mature weight of cows is assumed to evoke a proportional increase in mature weight of bulls of the same breed. A correlated increase in the optimal slaughter weight of fattened animals is assumed as well. Furthermore, it is assumed that heifers are firstly mated after reaching a minimal weight required for mating; this weight is expressed as a proportion of mature weight. An increase in mature weight is therefore assumed to cause an increase in the minimal weight required for mating (which is an input parameter). As the growth rate of calves is kept constant, an increase in mature weight causes an increase of the age of dairy heifers at first insemination (Production System 4, program EWDC) and a decrease of the proportion of beef heifers firstly mated in the first mating period after their weaning (Production Systems 1 to 3, program EWBC).

2.6.1.2 Birth weight

The effect of birth weight on calving performance or calf mortality is not included when calculating the economic weight of birth weight because calving performance and calf mortality are evaluated separately. A change in birth weight (keeping the growth rate in all following growth periods constant) causes a change in the weight of calves at fixed age and a change in the length of the fattening period because a fixed optimal slaughter weight of bulls, heifers or castrates is assumed. Alternative uses of saved production factors are assumed (i.e. a change in "fixed" costs in fattening is assumed to be caused by a change in the length of the fattening period). Furthermore, the effect of a change of birth weight on the age of dairy heifers at the first insemination and on the proportion of beef heifers mated in the first mating period after their weaning (see also explanation for mature weight, paragraph 2.6.1.1) is included in the economic value of birth weight.

2.6.1.3 Average daily gain of calves from birth to 1st weighing or weight gain from birth to 1st weighing

This trait is considered only for beef cattle (program EWBC). Average daily gain in the following periods (which are evaluated separately) is held constant when calculating the economic weight of this trait. The economic weight for daily gain can be converted to the economic weight of **weight gain of calves from birth to the 1st control weighing**.

A change of daily gain influences the weight of calves at the following weighings and the length of the fattening period, because a fixed optimal slaughter weight

of bulls, heifers and castrates is assumed. Furthermore, changing the growth rate affects the age of dairy heifers at the first insemination and the proportion of beef heifers mated in the first mating period after their weaning. As the age of cows (and bulls) at mature weight and mature weight are held constant, the average daily gains in the growth periods of cows and bulls are assumed to decrease when increasing the growth rate of calves.

2.6.1.4 Average daily gain of calves from 1st to 2nd weighing or weight gain from 1st to 2nd weighing

This trait is considered only for beef cattle (program EWBC). Average daily gain in the previous and the following periods is held constant when calculating the economic weight. The economic weight for daily gain can be converted to the economic weight of **weight gain of calves from 1st to 2nd weighing**. The same assumptions as for the foregoing trait are used for the calculation of the economic value of this trait.

2.6.1.5 Average daily gain of calves from 2nd to 3rd weighing or weight gain from 2nd to 3rd weighing

This trait is considered only for beef cattle (program EWBC). Average daily gain in the previous periods are held constant when calculating the economic weight. The economic weight for daily gain can be converted to the economic weight of **weight gain of calves from 2nd to 3rd weighing**. The same assumption as given by the foregoing growth rates are used for the calculation of the economic value of this trait.

2.6.1.6 Average daily gain of calves in the rearing period

This trait is evaluated only in Production System 4 (program EWDC). The economic value of this trait takes into account correlated changes in daily gain of heifers until calving and of breeding bulls till selling (if bulls are reared on farm). Also the effect of average daily gain on the age of heifers at first mating is considered when calculating the economic value as heifers are mated at fixed weight. As the age of cows (and bulls) at reaching mature weight and the mature weight are held constant, average daily gain in the growth periods of cows and bulls decreases when changing the growth rate of calves.

2.6.1.7 Average daily gain in the fattening period to constant slaughter weight

The average daily gain in the previous periods is held constant when calculating the economic weight of this daily gain. A change in daily gain in fattening causes a change in the length of the fattening period as a fixed optimal slaughter weight is assumed for all fattened animals. Again, an alternative use of saved production factors is assumed (i.e. a change in "fixed" costs in fattening is assumed when changing the length of the fattening period).

2.6.2 Carcass traits

2.6.2.1 Dressing percentage

The calculation of the economic value of dressing percentage is based on similar principles as the calculation of economic values of growth traits (taking dressing

percentage of fattened heifers as a reference trait and taking into account proportional changes of dressing percentage in bulls and castrates). In systems producing their own replacement (Production Systems 1, 2 and 4), a proportional increase in dressing percentage of cows is also assumed.

2.6.2.2 Average class of fleshiness and fat covering of carcass

The traits are defined as average classes for fleshiness and fat covering in fattened animals and culled cows and heifers. The numbers of classes for fleshiness and fat covering are input parameters in the input file INPUT08.TXT for beef cattle (see Section 4.2.7) and in INPUT23.TXT for dairy cattle (see Section 4.3.7). When calculating economic values for fleshiness and fat covering, at first separate economic values for heifers, bulls, castrates and cows are calculated and expressed per cow per year. The cumulative economic value is then calculated as the sum of the economic values for the four animal groups. Changes in the average class of fleshiness or fat covering are assumed to influence only the price per kg carcass (i.e. revenues for slaughtered and culled animals). No changes in any costs are taken into account.

2.6.3 Feed intake traits

Feed intake of animals is characterised by the residual daily dry matter intake (DMI) of a defined animal group in a defined feeding period. Residual DMI measures whether an animal eats more or less feed than predicted by published feeding standards or by comparison with measured feed intakes of like-type animals (e.g., same breed, sex, age) eating the same feed [6]. In the program, the predicted DMI for the defined animal categories is calculated according to equations published for the calculation of the energy and protein requirements for growth, maintenance, milk production and pregnancy and according to dry matter, net energy and protein (in PDI) content in the feed rations for these categories (see Subsection 2.4). The actual DMI is then calculated by adding the residual DMI (which is an input parameter) to the predicted one. The economic values for residual daily DMI are calculated separately for four animal groups which are calves, breeding heifers, cows and animals in fattening in program EWDC for dairy cattle; in EWBC, the program for beef cattle, these four groups are as follows: breeding heifers, animals in extensive fattening, animals in intensive fattening and adult animals (cows and breeding bulls). The economic values for these traits are calculated only if data for residual feed intake of the corresponding animal categories are available and are of interest (option in file PARA.TXT or PARAD.TXT).

Based on the definition of the residual DMI, the average residual DMI for a given group of animals should be zero [3, 19], and this value was also inserted in all input files with example data which are part of the program package. Nevertheless, input parameters different from zero are allowed.

2.6.3.1 Daily residual dry matter intake of calves in the rearing period (only in EWDC)

The residual daily DMI of female and male calves is assumed to be the same trait. Generally, two feeding periods are distinguished in rearing calves. It is assumed that the residual daily DMI of calves in both periods is the same trait (i.e. a higher residual DMI in the first feeding period will cause also a higher residual DMI in the second feeding period). When calculating the economic value for the residual daily DMI of calves, the average values of the residual daily DMI in both sexes and both feeding periods are increased and decreased by 0.005 kg DM/day. The change in profit per cow per year is then divided by the change in the residual daily DMI (i.e.

by 0.01 kg DM/day. The unit for the economic value of the residual daily DMI of calves is therefore given in monetary units per kg residual daily DMI and per cow per year.

2.6.3.2 Daily residual dry matter intake of breeding heifers in rearing

In EWDC, the period for which the residual daily DMI of heifers is defined covers the time from the end of rearing calves to first calving. In EWBC, the residual daily DMI is defined separately for summer and winter feeding.

2.6.3.3 Daily residual dry matter intake of cows (EWDC)

The period for which the residual daily DMI of cows is defined covers the whole calving interval in dairy cattle. It is assumed that a cow which will have a low or a high residual daily DMI in the first lactation will have also a low or a high residual daily DMI in the following lactations (i.e. the repeated expressions of the trait in different lactations are assumed to be the same trait).

2.6.3.4 Daily residual dry matter intake of adult animals (EWBC)

Residual DMI is differentiated between summer and winter feeding in beef cattle. It is assumed that a cow which will have a low or a high residual daily DMI in the first reproductive cycle will have also a low or a high residual daily DMI in the following reproductive cycles (i.e. the repeated expressions of the trait in different lactations are assumed to be the same trait). Residual DMI of breeding bulls for natural mating is taken into consideration when calculating the economic value for residual DMI of adult animals.

2.6.3.5 Daily residual dry matter intake of animals in fattening

In program EWDC, only intensive fattening of surplus progeny is assumed. In program EWBC, bulls are always intensively fattened, whereas heifers and castrates are either intensively fattened or extensively fattened on pasture. Daily DMI of fattened animals is assumed to be the same trait in all sexes. Generally, three sexes, heifers, bulls and castrates are distinguished. Therefore, a change in residual DMI of fattened animals achieved through selection of one sex is expected to be expressed in all three sexes. The period for which the residual daily DMI of fattened animal is defined covers the period from the end of rearing calves to slaughter of animals. In extensive fattening, winter and summer feeding and optionally finishing after pasture are distinguished.

2.6.4 Functional traits

2.6.4.1 Average score for calving performance

Up to six scores for calving performance are allowed and the number of classes is not fixed. For defining dystocia, the user of the programs EWBC and EWDC has to give the lowest number of the score of calving performance which is considered to be dystocia (in input files INPUT02.TXT or INPUT11.TXT, respectively (see on page 66 or on page 90). Scores equal to or greater than that value (mostly 3) are called dystocia, scores less than that value are called easy calving. The trait is expressed as average score for calving performance.

When calculating the economic value of calving performance, a similar approach is applied as for fleshiness or fat covering. Economic values are calculated separately for calving performance when a female was born and for calving performance when a

male was born. Afterwards, both values are summed to obtain one economic value. A modification of the average score for calving performance has an impact on the culling rate of cows (resulting in a change in the age structure of the cow herd and, in dairy cows [program EWDC], also in a change in the total milk production), the proportion of calves stillborn and died until 48 hours after birth and the conception rate.

However, these assumptions do not cause a double-counting for the effect of changes in milk yield, calf losses or conception rate on profit, because when calculating the economic values for the traits just mentioned, the average score for calving performance is kept constant (see also [27]).

2.6.4.2 Losses of calves at calving

Losses of calves at calving included cow aborts, calves born dead and calves died till 48 hours after calving. Calf losses at calving are defined as the number of dead calves expressed as proportion of the number of calvings in one reproductive cycle of the cow herd for the given dystocia rate.

2.6.4.3 Losses of calves from 48 hours till weaning or till the end of the rearing period

This trait is defined as number of dead calves expressed as proportion of the number of calves alive after 48 hours after calving in one reproductive cycle of the cow herd.

2.6.4.4 Conception rate of heifers or interval between 1st mating and conception of heifers

Conception rate is defined as the number of heifers conceived in their 1st oestrus in the given mating period expressed as proportion of the heifers mated in this mating period (reference trait per unit of which the economic value is expressed). When calculating the economic value, a proportional increase in the conception rates of heifers in their following oestrus cycles in the same mating period is assumed.

Conception rate of heifers directly influences the interval between the 1st mating and conception of heifers and therefore also the age at first calving. The economic value of this interval (only for dairy heifers) was calculated on the basis of profit changes caused by changes in the conception rate of heifers. In program EWDC, the interval between the 1st mating and conception of heifers may be alternatively used to conception rate of heifers (see INPUT31.TXT on page 114). The economic weight of the interval between the 1st mating and conception should be similar to the economic weight of age at first calving which is not calculated in the program package ECOWEIGHT.

2.6.4.5 Conception rate of cows or calving interval

Conception rate of cows is defined as the number of cows after easy calving conceived in their 1st oestrus in the given mating period expressed as proportion of the cows mated after easy calving in this mating period (reference trait). A proportional change in the conception rates of cows after easy calving in their next oestrus cycles in the same mating period is assumed. Likewise, proportional changes in the conception rate of cows after dystocia are taken into account[9]. The economic value of this trait is calculated in the same way as described for heifers.

[9] Conception rate after dystocia is expressed as fraction of the conception rate after easy calving using the input parameter "Average decrease in conception rate of cows after having dystocia ..." from INPUT03.TXT (program EWBC) or from INPUT11.TXT (program EWDC). The value 0.15 used in example data was taken from [10].

Conception rate of cows influences directly the interval between the 1st mating after calving and conception and, therefore, the length of the calving interval. The economic value of the calving interval (only for dairy cows) was calculated on the basis of profit changes caused by changes in the conception rate of cows. In program EWDC, the calving interval may be used alternatively to conception rate of cows (see INPUT31.TXT on page 114). In systems with seasonal calving, the average calving interval is no indicator of the reproductive ability of the cows. Therefore, the economic weight of this trait is not calculated in program EWBC.

Changes in the conception rate of cows have impact on the number of cows culled for failure to conceive and change the age structure of the herd influencing many revenues and costs. When calculating the economic value of cow conception rate in dairy cattle (program EWDC), the length of the dry period of cows is held constant. Therefore a change in the conception rate results in a changed length of the calving interval and of the lactation period. The value of milk yield gained (or lost) through the change in the lactation length is considered in the calculation of the economic value of cow conception rate (or calving interval).

2.6.4.6 Cow losses

Cow losses are defined as cows not surviving to the next reproductive cycle expressed as proportion of the cows entering the given reproductive cycle excluding the cows culled due to problems caused by dystocia, due to low milk production or due to failure to conceive. Cow losses in each reproductive cycle are calculated as the sum of cows died and cows culled for health problems other than dystocia. When calculating the economic value of this trait, proportional changes in cow losses in all reproductive cycles are carried out. The economic value is expressed per change in the weighted average of cow losses over all reproductive cycles.

The changes of cow losses have a direct impact on the length of productive lifetime of cows. Therefore, the change in profit due to the change of cow losses can be expressed also per unit of cow lifetime. Average lifetime of a cows is therefore an alternative definition of the trait cow losses. It is calculated as the **average productive lifetime** of all heifers that entered the herd.

A change in cow losses alters the age structure of the cow herd having consequences on many revenues and costs.

2.6.4.7 Somatic cell score

The economic value of this trait is calculated only in program EWDC. Somatic cell count (SCC) is defined as the average number of somatic cells per ml milk. The somatic cell score (SCS) is calculated from the somatic cell count as follows [15, 2]:

$$SCS = \log_2\left(\frac{SCC}{100000}\right) + 3 \tag{2.40}$$

In the opposite way, the somatic cell count can be calculated from the somatic cell score:

$$SCC = 100000 \times 2^{SCS-3} \tag{2.41}$$

It is assumed that somatic cell score influences only the milk price.

2.6.4.8 Mastitis incidence

The economic value of this trait is calculated only in program EWDC. Mastitis incidence is defined as the average clinical mastitis incidence (number of clinical mastitis cases per cow-year at risk in the herd). Costs and revenues connected with mastitis incidence are described in detail in [25].

2.6.4.9 Claw disease incidence

The economic value of this trait is calculated only in program EWDC. Claw disease incidence is defined as the number of claw disease cases per cow-year at risk in the herd.

2.6.5 Milk production traits

These traits are calculated only in production system 4 (program EWDC). Milk yield, milk fat, milk protein and milk coagulation traits are considered.

2.6.5.1 Milk yield

The trait is defined as the average 305-day milk yield (with constant fat and protein content[10]) per cow. The economic value of this trait is calculated by multiplying the whole lactation curve with a factor (1.005: for increasing the trait, 0.995: for decreasing the trait). This procedure preserves the shape of the lactation curve. A change in the milk yield after 305 days of lactation is included when calculating the economic value for the average 305-d milk yield. Therefore, the economic value of milk yield is also influenced by the calving interval.

2.6.5.2 Fat content in milk

The trait is defined as fat yield per kg milk at constant milk yield and is expressed in per cent. An alternative trait expression is **fat yield** in kg in a 305d-lactation, but also in this case the milk yield is held constant that means that an increase in fat yield is given through increasing the fat content.

2.6.5.3 Protein content in milk

The definition of protein content and **protein yield** is in the same sense as for fat content and fat yield.

2.6.5.4 Rennet coagulation time (milk coagulation time)

Rennet coagulation time (RCT) is the time (in minutes) from the addition of rennet to milk to the beginning of coagulation. During the cheese-making process, curd is cut at fixed time (usually 30 min) after the addition of rennet to the milk. Therefore, it is expected that prolonged rennet coagulation time will cause smaller curd which means lower yield of cheese from the same amount of milk with given quality (fixed milk composition and quality). No additional costs are expected when changing rennet coagulation time. In the present version of program EWDC, rennet coagulation time is expected to influence only the milk price (see Subsection 2.5.1.2).

2.6.5.5 Curd firmness

Curd firmness ($a30$) is the width of the curd (in millimetres) 30 min after the addition of rennet. Milk with zero curd firmness is called non-coagulating milk. Curd firmness influences directly cheese yield. No additional costs are expected when changing curd firmness. In the present version of program EWDC, also curd firmness is expected to influence only the milk price (see Subsection 2.5.1.2).

[10] The particular values of fat and protein content are input parameters.

2.7 Calculation of economic values

2.7.1 Traits with continuous variation: standard situation

The *marginal economic value* (ev) is defined as the partial derivative of the profit with respect to the trait considered. Let TV_h be the value of the trait considered which was derived as $TV_h = 1.005TV_{av}$ that means by increasing the average value of the trait TV_{av} by 0.5%. Similarly, TV_l is calculated by decreasing the average trait value by the same amount: $TV_l = 0.995TV_{av}$. Furthermore, let TP_h and TP_l be the total profit belonging to TV_h or TV_l, respectively. The partial derivative is then approximated by the following difference quotient:

$$ev = \frac{TP_h - TP_l}{TV_h - TV_l} \ . \tag{2.42}$$

The marginal economic value is expressed in monetary units (MU) per unit of the trait, per cow entering the reproductive cycle and per year[11].

2.7.2 Traits with continuous variation: residual dry matter intake

Residual dry matter intake (traits 30 to 33 in EWBC and 42 to 45 in EWDC, see Appendix A.2 on page 127) may have an average of zero. Therefore, the procedure as given in Subsection 2.7.1 for the calculation of the economic value cannot be applied. TV_h and TV_l are here calculated by adding and subtracting a constant (0.05) to or from TV_{av}: $TV_h = TV_{av} + 0.05$, $TV_l = TV_{av} - 0.05$. Then again equation 2.42 is used to calculate the economic value.

2.7.3 Categorical traits: standard situation

The economic values for categorical traits (calving performance, fleshiness and fat covering) are calculated according to [26]. The calculation is based on a threshold model. The underlying normal distribution is shifted to the left and to the right, each time by 0.05 standard deviations. The resulting changes in the distribution are converted to changes in the average class. For the numerical expression of the average class, the numbers 1 to N are assigned to the individual classes. Let p_i be the frequency of animals in class i. Then the average class AC is calculated simply as

$$AC = \sum_{i=1}^{N} ip_i \ . \tag{2.43}$$

Let AC_h be the average class for shifting the distribution to higher values of the trait and let AC_l be the average class for shifting the distribution to lower values of the trait. Furthermore, let TP_h and TP_l be the total profit belonging to the first or the second of these values, respectively. Then the marginal economic value ev is calculated as change of total profit related to a change in the average class by 0.01:

$$ev = 0.01\frac{TP_h - TP_l}{AC_h - AC_l} \ . \tag{2.44}$$

[11] see also Subsection 2.6.1 on page 34.

2.7.4 Categorical traits: atypical situation with only one class

In extreme situations it can happen that all data are in one class only. In this case it will not be possible to estimate the thresholds of the underlying normal distribution. We suppose to develop an automatic procedure in the program for this case in future. At the moment, we recommend the following procedure to get out of this situation. Change your input values in the way that you allocate a very small amount of data to the neighbouring classes. For example, there are 100% data in class 2. Then the situation will not considerably change when assigning 1% to each of classes 1 and 3 and leave 98% in class 2. The mean class will be the same as before and the calculation of the economic values will work. ***But you should ponder if it will make sense to calculate an economic weight in such a situation without measurable variability.***

2.7.5 Calculation of economic values in the situation with milk quota

For calculating economic values under the situation with quota, the total profit will be rewritten as

$$TP = n_{cow} TP_0 \tag{2.45}$$

where n_{cow} is the number of cows and TP_0 the total profit per cow. Generally, the economic value is defined as partial derivation of the total profit with respect to the given trait which can be numerically approximated by the difference quotient (see equation (2.42)). If there is a milk quota, the total amount of milk is assumed to stay constant. An increase in the amount of milk is then reflected by a decrease in the number of cows. We can write

$$ev = \left.\frac{\partial TP}{\partial TV}\right|_{TV=TV_{av}} = \frac{\partial n_{cow}}{\partial TV} TP_{0[av]} + \frac{\partial TP_0}{\partial TV} n_{cow[av]} \tag{2.46}$$

where TV is the value of the given trait, TV_{av} is the average of the given trait in the population, $TP_{0[av]}$ is the value of the total profit per cow when all traits take their average values and $n_{cow[av]}$ is the number of cows when all traits take their average values. As the total profit is calculated per cow, $n_{cow[av]} = 1$.

Numerically the marginal economic value is then calculated as

$$ev = \frac{n_{cow[h]} - n_{cow[l]}}{TV_h - TV_l} TP_{0[av]} + \frac{TP_h - TP_l}{TV_h - TV_l} \tag{2.47}$$

where TV_h, TV_l, TP_h and TP_l have the same meaning as in (2.42) and $n_{cow[h]}$ and $n_{cow[l]}$ are the number of cows for the high or the low value of the trait (TV_h or TV_l, respectively). The first term in equation(2.47) is zero for all traits the change of the value of which is of no influence on the total amount of milk and therefore on the number of cows.

A fat quota has only impact on the calculation of the economic weight for milk fat content and milk fat yield. A change in the fat content will cause a change in the total amount of fat which must be counterbalanced by an adequate change in the number of cows.

2.7.6 Remark to the calculation of economic values in Production System 4

In System 4, traits expressed in pure-bred (dairy) and cross-bred (dairy x beef) animals are treated separately. That means, the economic values are calculated in separate program loops for pure-bred and cross-bred animals and expressed per

dairy cow and year. The reason for this approach is the fact shown in many studies that the economic values depend on the level of the trait (e.g. Wilton et al. 2002 [20]). As there are mostly considerable differences between the performance of pure-bred and cross-bred animals this procedure seems to be justified.

If there is a connection with Production System 3 via the file FROM1_3.TXT (see Subsection 4.3.19 on page 117), a third set of economic values is printed which is expressed per cow in System 3 and per year.

2.7.7 Relative marginal economic values

The marginal economic values of the individual traits cannot be compared among each other as they have different units. One way to make the economic weights comparable is to refer them to the genetic standard deviation of the trait. The so-called standardised marginal economic value ($evst_s$) for trait s is calculated as[12]:

$$evst_s = ev_s \times \sigma_{gs} \tag{2.48}$$

where σ_{gs} is the genetic standard deviation of trait s. The standardised marginal economic values are given in monetary units per standard deviation of the trait and per cow and year.

As the standardised marginal economic values have the same units for all traits, they can be expressed as percentage of the sum of all standardised marginal economic values. When calculating the sum, care must be taken not to include the same trait twice. Therefore, both in program EWBC and in program EWDC you must choose always one trait definition from two alternatives for four or eight pairs of definitions describing always the same trait in different ways (in input files INPUT34.TXT and INPUT31.TXT, respectively, see Subsections 4.2.18 and 4.3.14).

As both positive and negative values occur it is useful to calculate the sum ($evsum$) from the absolute values of the marginal economic values:

$$evsum = \sum_s \text{abs}(evst_s) \ . \tag{2.49}$$

The sum considers only traits which are evaluated. The relative marginal economic values are calculated as:

$$evr_s = 100 \times \frac{\text{abs}(evst_s)}{evsum} \ . \tag{2.50}$$

2.7.8 Final remarks

Read carefully the output of the program when considering the economic values. The economic values for daily gain will be given per gramme per day, the trait itself has the unit kg per day. Therefore, do not read only the numbers, but also the units belonging to them. Furthermore, an increase in the average value of a trait does not always mean an improvement of the trait. Take this fact into account when interpreting the sign of the economic values.

[12] In program EWDC, this quantity is calculated only if there is no crossbreeding.

2.8 Gene flow, number of discounted expressions for maternal and direct effects of traits and economic weight for direct and maternal effects of traits

In general, all traits can be divided in two main groups: (i) direct traits realised once in the life of an animal and (ii) maternal traits realised repeatedly during the life of dams [24]. For the definition of direct and maternal traits in the context with economic weights and for some discussion on this topic see also [29]. Some traits have both direct and maternal components (calving performance, growth)[13]. Although the economic values for both components of a trait could be the same (e.g. for calving performance), the number of expressions for these components transmitted by bulls are different and depend also on the production system (e.g. the number of expressions for maternal calving performance of beef bulls is zero in Production System 3). To take this fact into account when defining the breeding goal for beef or dairy bulls in different production systems, the calculation of the number of discounted expressions for the two groups of traits and the selection groups of interest (beef bulls, beef dams, dairy bulls, dairy dams) has been included in the program. The gene flow method developed by Hill [7] and Elsen and Mocquot [4] is applied for this calculation. The number of discounted expressions for trait group j and selection group k in production system p is calculated as follows (see also Nitter et al. [11]):

$$NDE_{jkp} = \mathbf{h'_j} \sum_{t=1}^{T} \mathbf{m_k^{[t]}} (1+u)^{-t} \tag{2.51}$$

with

$$\mathbf{m_k^{[t]}} = \mathbf{P_p m_k^{[t-1]}} = \mathbf{P_p^2 m_k^{[t-2]}} = \cdots = \mathbf{P_p^t m_k^{[0]}} \tag{2.52}$$

where T is the investment period (in years) during which the gene expressions are summarised, $\mathbf{m_k^{[t]}}$ is a vector whose elements define the proportion of genes in each sex-age class at time t that come from the original group k of selected animals at time 0, $\mathbf{P_p}$ is the matrix of transmission probabilities for production system p which relates the proportion of genes in each sex-age class represented in $\mathbf{m_k^{[t-1]}}$ to the proportion of genes of the sex-age classes in $\mathbf{m_k^{[t]}}$, $\mathbf{h_j}$ is a vector which describes the realisation of trait group j ($\mathbf{h'_j}$ is the transpose of $\mathbf{h_j}$) and u is the discount rate per year.

Notice that within both groups of traits the NDE_{jkp} are equal for all traits because the marginal economic values of all traits are expressed per cow and year and discounted to the time of calving (to birth of progeny). The number of animals in different categories (born per cow and year) expressing a certain trait and the time delay between the expression of this trait and the animal's birth are already taken into account in the calculation of the marginal economic values. Therefore, the NDE in Section 2.5 represent differences in expressions of traits within one generation of progeny. The NDE_{jkp} calculated in this section, on the other hand, show the transmission of genetic superiority of selected animals for direct or maternal traits to subsequent generations during the investment period.

[13] A survey which trait components (direct and/or maternal) the economic weights are calculated for is given in Appendix A.2 for all traits.

2.8.1 Matrix $\mathbf{P_p}$ for Systems 1 to 3

Transmission matrix $\mathbf{P_p}$ differs between production systems. In Production System 1, it looks as follows:

$$\mathbf{P_p} = \mathbf{P}_1 = \begin{array}{c} \\ \text{Sires} \\ \\ \\ \\ \\ \\ \\ \text{Dams} \\ \\ \\ \\ \\ \\ \\ \text{Slaughter animals} \end{array} \begin{array}{c} \begin{array}{cccccc|cccccc|c} \text{Sires} & & & & & & \text{Dams} & & & & & & \text{Slaughter animals} \end{array} \\ \left[\begin{array}{cccccc|cccccc|c} x & x & x & \cdots & x & x & x & x & x & \cdots & x & x & 0 \\ 1 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 1 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 1 & \cdots & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 0 & \ddots & 0 & 0 & 0 & 0 & 0 & \ddots & 0 & 0 & 0 \\ 0 & 0 & 0 & \cdots & 1 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ \hline x & x & x & \cdots & x & x & x & x & x & \cdots & x & x & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 1 & 0 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 1 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 1 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 0 & \ddots & 0 & 0 & 0 & 0 & 0 & \ddots & 0 & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & \cdots & 1 & 0 & 0 \\ \hline x & x & x & \cdots & x & x & x & x & x & \cdots & x & x & 0 \end{array}\right] \end{array}$$

The matrix has a block structure containing 3x3 blocks in Production Systems 1 to 3. The blocks are made up by age classes of sires, age classes of dams and one class of slaughter animals. The elements $P_{ii'}$ of $\mathbf{P_p}$ are the proportions of genes in the sex-age class i at time t which come from the sex-age class i' at time $t-1$. The sum of all elements $P_{ii'}$ within each row is 1 and the sum of all elements $P_{ii'}$ within each row belonging to the same sex is 0.5. The symbol x designates elements which can be different from zero (The values of x are in the range from 0 to 0.5).

In Production System 2, matrix $\mathbf{P_p}$ has the following structure:

$$\mathbf{P_p} = \mathbf{P}_2 = \begin{array}{c} \\ \text{Sires} \\ \\ \\ \\ \\ \\ \\ \text{Dams} \\ \\ \\ \\ \\ \\ \\ \text{Slaughter animals} \end{array} \begin{array}{c} \begin{array}{cccccc|cccccc|c} \text{Sires} & & & & & & \text{Dams} & & & & & & \text{Slaughter animals} \end{array} \\ \left[\begin{array}{cccccc|cccccc|c} 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 0 & \ddots & 0 & 0 & 0 & 0 & 0 & \ddots & 0 & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ \hline x & x & x & \cdots & x & x & x & x & x & \cdots & x & x & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 1 & 0 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 1 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 1 & \cdots & 0 & 0 & 0 \\ 0 & 0 & 0 & \ddots & 0 & 0 & 0 & 0 & 0 & \ddots & 0 & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & \cdots & 1 & 0 & 0 \\ \hline x & x & x & \cdots & x & x & x & x & x & \cdots & x & x & 0 \end{array}\right] \end{array}$$

and in Production System 3 non-zero elements are conserved only in the last row of the matrix.

2.8.2 Matrix $\mathbf{P_p}$ for System 4

In Production System 4 with terminal crossing and with connection to System 3 (if cross-bred beef × dairy heifers from Production System 4 are transferred to cow-calf pasture System 3), transmission matrix $\mathbf{P_p}$ has 7 x 7 block structure:

$$\mathbf{P_p} = \mathbf{P_4} = \begin{bmatrix} \mathbf{P_{11}} & \cdots & \mathbf{P_{17}} \\ \vdots & \ddots & \vdots \\ \mathbf{P_{71}} & \cdots & \mathbf{P_{77}} \end{bmatrix} \tag{2.53}$$

The blocks represent age classes of beef sires, dairy dams, dairy sires (in System 4), cross-bred dams (in System 3), dairy slaughter progeny, cross-bred slaughter progeny of dairy dams (in System 4) and cross-bred slaughter progeny of cross-bred dams (in System 3). In the latter three blocks, there is always only one class. All sub-matrices of $\mathbf{P_p}$ have one of the following structures:

$$\mathbf{S_1} = \begin{bmatrix} x & x & x & \cdots & x & x \\ 1 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 1 & 0 & \cdots & 0 & 0 \\ 0 & 0 & 1 & \cdots & 0 & 0 \\ 0 & 0 & 0 & \ddots & 0 & 0 \\ 0 & 0 & 0 & \cdots & 1 & 0 \end{bmatrix}, \quad \mathbf{S_2} = \begin{bmatrix} x & x & x & \cdots & x & x \\ 0 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 0 & 0 & \ddots & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 \end{bmatrix},$$

$$\mathbf{S_3} = \begin{bmatrix} x & x & x & \cdots & x & x \end{bmatrix}, \quad \mathbf{S_4} = \begin{bmatrix} 0 & 0 & 0 & \cdots & 0 & 0 \\ 1 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 1 & 0 & \cdots & 0 & 0 \\ 0 & 0 & 1 & \cdots & 0 & 0 \\ 0 & 0 & 0 & \ddots & 0 & 0 \\ 0 & 0 & 0 & \cdots & 1 & 0 \end{bmatrix}.$$

The sub-matrices $\mathbf{P_{22}}$, $\mathbf{P_{33}}$ are of structure $\mathbf{S_1}$, the sub-matrices $\mathbf{P_{23}}$, $\mathbf{P_{32}}$, $\mathbf{P_{41}}$ and $\mathbf{P_{42}}$ are of structure $\mathbf{S_2}$, the sub-matrices $\mathbf{P_{11}}$ and $\mathbf{P_{44}}$ are of structure $\mathbf{S_4}$ and the blocks $\mathbf{P_{52}}$, $\mathbf{P_{53}}$, $\mathbf{P_{61}}$, $\mathbf{P_{62}}$ and $\mathbf{P_{74}}$ are of structure $\mathbf{S_3}$. All other blocks consist only of elements being zero. The elements of $\mathbf{P_{74}}$ sum up to 0.5 and not to one or zero as in all other rows of matrix $\mathbf{P_p}$. If no connection exists between Systems 4 and 3 (all cross-bred progeny are fattened in System 4) all elements of the sub-matrices $\mathbf{P_{41}}$, $\mathbf{P_{42}}$, $\mathbf{P_{44}}$ and $\mathbf{P_{74}}$ are zero.

The potential non-zero elements in matrices $\mathbf{P_p}$ designated with the symbol "x" depend on the breeding program and are input parameters. There is an exception in the path dams to breed dams. The non-zero elements in this block are a result of the herd structure in the stationary state and are calculated by the program on the basis of the input parameters determining the herd structure.

2.8.3 Vectors $\mathbf{m_k}$, $\mathbf{h_d}$ and $\mathbf{h_m}$ for Production Systems 1 to 3 (Program EWBC)

Assume that $k = 2$ that means the selection group of interest are bulls in the second age class. Then the transpose of vector $\mathbf{m_k^{[0]}}$ is:

$$\mathbf{m_2^{[0]\prime}} = \left[\begin{array}{cccccc|cccccc|c} 0 & 1 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 \end{array}\right] \tag{2.54}$$

The realisation vectors for direct traits ($\mathbf{h'_d}$) and for maternal traits ($\mathbf{h'_m}$) have the same dimension as $\mathbf{m_k^{[0]}}$ and are of the following form:

$$\begin{array}{rcl} \mathbf{h'_d} & = & [\ 0\ \ 0\ \ 0\ \ \cdots\ \ 0\ \ 0\ \mid\ 0\ \ 0\ \ 0\ \ \cdots\ \ 0\ \ 0\ \mid\ 1\ ] \\ \mathbf{h'_m} & = & [\ 0\ \ 0\ \ 0\ \ \cdots\ \ 0\ \ 0\ \mid\ p_{f1}\ \ p_{f2}\ \ p_{f3}\ \ \cdots\ \ p_{fn-1}\ \ p_{fn}\ \mid\ 0\ ] \end{array} \tag{2.55}$$

where p_{fi} is the proportion of cows calving in age classes 1 to n. The elements of $\mathbf{h'_m}$ sum up to 1.

2.8.4 Vectors $\mathbf{m_k}$, $\mathbf{h_d}$ and $\mathbf{h_m}$ for Production System 4

In Production System 4 with a possible connection to Production System 3, the realisation vectors for direct traits $\mathbf{h_d}$ and for maternal traits $\mathbf{h_m}$ are of the following form:

$$\begin{array}{rcl} \mathbf{h'_d} & = & [\ \mathbf{0'}\ \mid\ \mathbf{0'}\ \mid\ \mathbf{0'}\ \mid\ \mathbf{0'}\ \mid\ p_{dd}\ \mid\ p_{db}\ \mid\ p_{cr}\ ] \\ \mathbf{h'_m} & = & [\ \mathbf{0'}\ \mid\ \mathbf{p'_{d4}}\ \mid\ \mathbf{0'}\ \mid\ \mathbf{p'_{cr}}\ \mid\ 0\ \mid\ 0\ \mid\ 0\ ] \end{array} \tag{2.56}$$

with $\mathbf{0'}$ being a row vector with zeros

$$\mathbf{0'} = [\ 0\ \ 0\ \ \cdots\ \ 0\ ] \tag{2.57}$$

and

$$\begin{array}{rcl} \mathbf{p'_{d4}} & = & [\ p_{d41}\ \ p_{d42}\ \ \cdots\ \ p_{d4n_4}\ ] \\ \mathbf{p'_{cr}} & = & [\ p_{cr1}\ \ p_{cr2}\ \ \cdots\ \ p_{crn_c}\ ] \end{array} \tag{2.58}$$

where p_{dd} and p_{db} are the proportions of pure-bred and cross-bred calvings in System 4, respectively, ($p_{dd} + p_{db} = 1$), p_{cr} is the number of cross-bred dams in System 3 per dairy cow in System 4, the element p_{d4i} of the vector $\mathbf{p_{d4}}$ is the proportion of dairy cows in age class i ($i = 1, ..., n_4$) in System 4 ($\sum_{i=1}^{n_4} p_{d4i} = 1$) and the element p_{cri} of the vector $\mathbf{p_{cr}}$ is the proportion of cross-bred cows in System 3 calving in age class i ($i = 1, ..., n_c$) per dairy cow in System 4 ($\sum_{i=1}^{n_c} p_{cri} = p_{cr}$).

The variable p_{cr} is calculated as follows:

$$p_{cr} = \frac{l1[CC+23] \times tconh3}{pc3s_1} \tag{2.59}$$

where $l1[CC+23]$ is the number of cross-bred heifers sold to System 3 per dairy cow and per reproductive cycle in System 4 , $tconh3$ is the total conception rate of cross-bred heifers mated in System 3 and $pc3s_1$ is the proportion of cows on reproductive cycle 1 in System 3.

If no connection exists between Systems 4 and 3, all p_{cri} and consequently p_{cr} take the value of zero. *Note: Differentiate between the vector* $\mathbf{p_{cr}}$ *printed in bold and the sum of its elements* p_{cr} *printed in italics.*

The vectors of economic values for direct ($\mathbf{ev_{sd}}$) and maternal ($\mathbf{ev_{sm}}$) effects of trait s are as follows:

$$\begin{array}{rcl} \mathbf{ev'_{sd}} & = & [\ \mathbf{0'}\ \mid\ \mathbf{0'}\ \mid\ \mathbf{0'}\ \mid\ \mathbf{0'}\ \mid\ ev_{sdd}^{cal}\ \mid\ ev_{sdb}^{cal}\ \mid\ ev_{s3}^{cow}\ ] \\ \mathbf{ev'_{sm}} & = & [\ \mathbf{0'}\ \mid\ \mathbf{1'}(ev_{sdd}^{cow} + ev_{sdb}^{cow})\ \mid\ \mathbf{0'}\ \mid\ \mathbf{1'}ev_{s3}^{cow}\ \mid\ 0\ \mid\ 0\ \mid\ 0\ ] \end{array} \tag{2.60}$$

with $\mathbf{0'}$ and $\mathbf{1'}$ being row vectors with zeros and ones, respectively:

$$\mathbf{0'} = [\ 0\ \ 0\ \ \cdots\ \ 0\ ], \qquad \mathbf{1'} = [\ 1\ \ 1\ \ \cdots\ \ 1\ ] \tag{2.61}$$

where ev_{sdd}^{cal} or ev_{sdd}^{cow} is the economic value for trait s expressed in pure-bred dairy progeny (per pure-bred dairy calving or per dairy cow, respectively), ev_{sdb}^{cal} or ev_{sdb}^{cow} is the economic value for the same trait expressed in cross-bred progeny (per cross-bred calving or per dairy cow, respectively) and ev_{s3}^{cow} is the economic value for this trait expressed in System 3 (per cross-bred cow in System 3).

2.8.5 Calculation of economic weights

The economic weight $ew_{s(j)kp}$ for trait s within trait group j (two groups: direct and maternal traits) and selection group k in production system p (where $p = 1, 2$ or 3) is calculated as

$$ew_{s(j)kp} = ev_s NDE_{jkp} \tag{2.62}$$

where ev_s is the appropriate economic value calculated as described in Section 2.7 and NDE_{jkp} is the number of discounted expressions for the given group of traits j and the given selection group k in production system p from equation (2.51).

In System 4 where cross-bred replacement females for System 3 can be supplied, a somewhat different approach is used for the calculation of economic weights, because the economic value for a given trait will be different when expressed in cross-bred progeny of System 4 or of System 3. Therefore, the realisation vectors $\mathbf{h_j}$ have to be multiplied by the vectors of economic values for traits expressed in the individual progeny groups. In this case, the economic weights in System 4 are calculated as

$$ew_{s(j)k4} = \mathbf{h_j'} \odot \mathbf{ev_{sj}'} \sum_{t=1}^{T} \mathbf{m_k}[\mathbf{t}](1+u)^{-t} \tag{2.63}$$

where ev_{sj} is the joint vector of economic values for trait s within trait group j in Systems 3 and 4. Its form is given above in Section 2.8.4. The symbol $\odot$ stands for the element-wise product of vectors.

The economic weight $ew_{s(j)k}$ for the general breeding goal of the evaluated beef breed and its selection group k for trait s across all production systems, where bulls of this breed are used, can then be estimated as

$$ew_{s(j)k} = \sum_p ew_{s(j)kp} nc_p \tag{2.64}$$

where nc_p is the proportion of cows in production system p with $\sum_p nc_p = 1$. This calculation is not a part of the program.

2.9 Relative economic weights

The economic weights of individual traits as they are calculated in subsection 2.8.5 cannot be compared among each other as they have different units. One way to make the economic weights comparable is to refer them to the genetic standard deviation of the trait. These so-called standardised economic weights for the direct and the maternal trait components ($ewst_{sd}$ and $ewst_{sm}$, respectively[14]) are calculated as:

$$\begin{aligned} ewst_{sd} &= ew_{sd} \times \sigma_{gsd} \\ ewst_{sm} &= ew_{sm} \times \sigma_{gsm} \end{aligned} \tag{2.65}$$

[14] For simplicity, we omit here the indices for the selection group and the production system and replace the general index (j) by d or m for direct or maternal, respectively, traits and trait components.

where σ_{gsd} and σ_{gsm} are the genetic standard deviations for the direct or maternal component, respectively, of trait s. The standardised economic weights are given in monetary units per standard deviation of the trait component and per cow in the given production system.

As the standardised economic weights have the same units for all traits, they can be expressed as percentage of the sum of all standardised economic weights. When calculating the sum, care must be taken of not including the same trait twice. Therefore, in input files INPUT34.TXT (program EWBC, see Subsection 4.2.18) or INPUT31.TXT (program EWDC, see Subsection 4.3.14) you must choose always one trait definition from two alternatives for four or eight pairs, respectively, of definitions describing always the same trait in different ways.

As both positive and negative values occur it is useful to calculate the sum from the absolute values of the economic weights. It may be helpful to calculate this sum for the economic weights of the direct components of the traits ($ewsum_d$), for the economic weights of the maternal components of the traits ($ewsum_m$) and for both components together ($ewsum$):

$$\begin{aligned} ewsum_d &= \sum_{s=1}^{NT-1} \delta_{sd} \times \text{abs}(ewst_{sd}) \\ ewsum_m &= \sum_{s=1}^{NT-1} \delta_{sm} \times \text{abs}(ewst_{sm}) \end{aligned} \tag{2.66}$$

and

$$ewsum = ewsum_d + ewsum_m \ . \tag{2.67}$$

The variables δ_{sd} and δ_{sm} take only values 1 or 0 depending on considering or not considering the corresponding trait.

The following proportions of standardised economic weights (which are called relative economic weights) may be calculated:

- Standardised economic weight for the direct component of trait s expressed as percentage of the sum of all standardised economic weights for the direct components:
$$ewr\_dd_s = 100 \times \frac{\text{abs}(ewst_{sd})}{ewsum_d} \tag{2.68}$$
- Standardised economic weight for the maternal component of trait s expressed as percentage of the sum of all standardised economic weights for the maternal components:
$$ewr\_mm_s = 100 \times \frac{\text{abs}(ewst_{sm})}{ewsum_m} \tag{2.69}$$
- Standardised economic weight for the direct component of trait s expressed as percentage of the sum of all standardised economic weights for both the direct and the maternal components:
$$ewr\_da_s = 100 \times \frac{\text{abs}(ewst_{sd})}{ewsum} \tag{2.70}$$
- Standardised economic weight for the maternal component of trait s expressed as percentage of the sum of all standardised economic weights for both the direct and the maternal components:
$$ewr\_ma_s = 100 \times \frac{\text{abs}(ewst_{sm})}{ewsum} \tag{2.71}$$

Chapter 3

Installing and running the program

3.1 List of files in the installation package

PARA.TXT, PARAD.TXT Parameter files for the programs EWBC and EWDC, respectively (see Section 4.1) .

INPUTxx.TXT with xx = 01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35 or 36. Data input files. Not all files are required for each run. A survey which data input files are needed for a given combination of parameters in the parameter file is presented in Table 4.1 on page 65 for program EWBC and in Table 4.2 on page 88 for program EWDC. A detailed description of the data input files for program EWBC is given in Section 4.2. The input files for program EWDC are described in Section 4.3.

TEXT_OUT.TXT, TEXTD_OUT.TXT These files contain text for writing the results for the programs EWBC and EWDC, respectively. For details see Section 4.4.

ewbc.exe, ewdc.exe Executable program files for program EWBC and EWDC, respectively.

license (in subdirectory DOC) This file contains the license conditions. Read them carefully and do not use the program package ECOWEIGHT if you do not agree with the license conditions.

ECOWEIGHT01.pdf (in subdirectory DOC) Manual of the first part of program package ECOWEIGHT (programs for cattle).

ewbc.c, ewdc.c (in subdirectory SRC) Source codes of the programs EWBC and EWDC, respectively.

3.2 Installation

3.2.1 Under LINUX

The programs EWBC and EWDC come to you as a compressed tar-file with the name ECOWEIGHT01_{# of version}.tgz, for example ECOWEIGHT01_5_2_2.tgz contains the programs for cattle from version 5.2.2 of the program package. Copy this file to a directory of your choice and enter the command

tar xvf ECOWEIGHT01_{# of version}.tgz

for uncompressing and unarchiving the file. All files necessary for running the programs EWBC and EWDC will be installed in the same directory. The subdirectory DOC will contain the file with the license conditions and the manual of the programs as pdf-file. The subdirectory SRC will contain the source code of the programs EWBC and EWDC.

For compiling the source code using the compiler gcc you must use the option -lm, because otherwise the mathematical functions would not work. For example, for compiling the source file ewbc.c to receive the executable file ewbc.exe, type:

gcc -lm -o ewbc.exe ewbc.c

In some more recent versions of LINUX it may happen that this command may not work. Try then

gcc -o ewbc.exe ewbc.c -lm

3.2.2 Under Microsoft Windows

The Windows version of the program is distributed as zip file. It contains the compiled programs **ewbc.exe** and **ewdc.exe**. The programs were compiled under Cygwin (http:// www.cygwin.com) and run only in the presence of the file *cygwin1.dll* which is part of the Windows distribution. In more recent versions of Cygwin, also the file *cyggcc_s-1.dll* is necessary. Recently (in May 2011) we found that the programs compiled with Cygwin on our computers probably do not work well on all versions of Windows. If there are problems (for example you get "nan", i.e. "not a number" for some results) install Cygwin on your Windows computer and compile the program on the computer on which the calculalations should be carried out. Cygwin is freely available. When compiling the source code, omit the option -lm:

gcc -o ewbc.exe ewbc.c

Alternatively it should be possible to use commercial C compilers (we did not test commercial compilers).

3.3 Running programs EWBC and EWDC

You are recommended to create one directory for each calculation where you will copy and edit all files you will need. The first thing you have to do is to choice a production system. Have a look to Tables 4.1 and 4.2 and decide which input files you need. All these input files must be edited and you have to insert the values of the system you are going to model.

3.3.1 Running program EWBC - Calculations for Production Systems 1 to 3

All data input files necessary for Systems 1 to 3 (see Table 4.1 on page 65), the files PARA.TXT, TEXT_OUT.TXT and the executable program file should be located in the same directory (alternatively, the executable program file can be located in

/usr/local/bin under LINUX). Edit the parameter file PARA.TXT and the data input files as described in Chapter 4. Enter under LINUX

./ewbc.exe or just **ewbc.exe** (if the program is located in /usr/local/bin)
or under Windows

ewbc.exe
to start the program.

The program will ask you to type the name of the output file the results will be written to. Press ENTER after typing the name of the file.

After finishing the program, you will find all results in the result file. This file is a text file and can be edited by any text editor or word processor.

3.3.2 Running program EWDC - Calculations for Production System 4

If a connection exists between the Production Systems 4 and 3, some results of System 3 are needed for the calculation of economic weights of traits for beef bulls in System 4. Therefore, in this case, System 3 had to be defined and EWBC had to be run before doing the calculation for System 4. The results from System 3 will be written to files FROM1_3.TXT and T.TXT. If there is no connection with System 3, data from file FROM1_3.TXT and T.TXT will be ignored.

All data input files necessary for Systems 4 (see Table 4.2 on page 88), the files PARAD.TXT, TEXTD_OUT.TXT, FROM1_3.TXT, T.TXT and the executable program file **ewdc.exe** should be located in the same directory (alternatively, the executable program file can be located in /usr/local/bin under LINUX). Edit the parameter file PARAD.TXT and the data input files as described in Chapter 4. Enter under LINUX

./ewdc.exe or just **ewdc.exe** (if the program is located in /usr/local/bin)
or under Windows

ewdc.exe
to start the program.

The program will ask you to type the name of the output file the results will be written to. Press ENTER after typing the name of the file.

After finishing the program, you will find all results in the result file. This file is a text file and can be edited by any text editor or word processor.

3.3.3 Example

Assume you want to calculate Production System 3 for variant 1 of fattening (see Section 4.1.1.3) and for the case that the parameters of the lactation curve are read in. Furthermore, you want to calculate relative economic weights for direct and maternal trait components. Then you should have in the directory for the calculation the following files (E means that you have to edit these files before starting the program):

- ewbc.exe
- PARA.TXT (E)
- INPUT01.TXT (E)
- INPUT02.TXT (E)
- INPUT03.TXT (E)
- INPUT04.TXT (E)

- INPUT06.TXT (E)
- INPUT08.TXT (E)
- INPUT10.TXT (E)
- INPUT14.TXT (E)
- INPUT16.TXT (E)
- INPUT17.TXT (E)
- INPUT20.TXT (E)
- INPUT26.TXT (E)
- INPUT34.TXT (E)
- INPUT35.TXT (E)
- TEXT_OUT.TXT

3.3.4 General remarks

Several checks of input parameters are included in the programs. For example, certain input parameters have to sum to one. A warning will appear if these input parameters are invalid and the program will stop. You will be told which input parameters are to be corrected before restarting the program. In general, it is your responsibility to use input parameters which are realistic and fit together, because it is impossible to predict any possible erroneous combinations of input parameters. Do not forget to have always a critical look on your results before using them for further purposes.

Chapter 4

Input files

Important remark: When editing the input files, keep attention *not to change quotation marks*. All files are read as sequential files and the program recognises the beginning and the end of texts on the basis of quotation marks. Adding or deleting a quotation mark will cause the program to break down or to calculate wrong results. Furthermore, do not use slashes (/) when changing some text, because slashes marks the beginning and the end of a comment.

Monetary unit: In all input files the abbreviation MU is used for monetary unit. All values in the distributed version of the program refer to Euros. You can globally replace the abbreviation MU by the abbreviation of your monetary unit in all data input files (INPUTxx.TXT) and in the input files TEXT_OUT.TXT or TEXTD_OUT.TXT using any text editor; the results file will then contain the monetary unit specified by you.

Language of the program: The program will need just the numbers for calculations. The texts are read in and printed out to the result file as they are. Therefore, you can freely change the text in all input files as long as you do not modify the quotation marks and do not use slashes. For example, you can translate all texts in the input files to another language what will cause the appropriate part of the result file to be printed in the same language as the input files (may be there are some exceptions where the English text will be remained). The length of the texts can be changed, but each text must start and finish with quotation marks. A great part of the text for the results file is read from the files TEXT_OUT.TXT or TEXTD_OUT.TXT. You can translate all the text in these two files. But be very careful not to change quotation marks.

4.1 Parameter files

The files PARA.TXT and PARAD.TXT contain basic information for the programs EWBC and EWDC, respectively. One row contains the value of the given parameter followed by a row with its description. Modify the values of the parameters according to the instructions given below. At the very beginning of each file there is space for writing a comment which helps you to identify the results. Replace the text in the example file by any text which must begin and end with quotation marks; quotation marks are not allowed to occur within the text.

4.1.1 Basic options of the production systems and for the calculation of economic weights

The following options are used as parameters in the parameter files PARA.TXT and PARAD.TXT.

4.1.1.1 Production system for cow herds

A cow-calf production system with extensive or intensive fattening of surplus progeny and eventually with selling of weaned calves or breeding heifers outside the system is assumed for Production Systems 1 to 3. For System 4, a classical system for dairy cows is assumed with intensive fattening or selling of surplus progeny; the dairy system may be connected with a cow-calf pasture system (System 3). The following variants are considered (see also Figure 1.1):

1 Pure-bred beef cow-calf pasture systems producing females and males for own replacement and for other systems. Both seed-stock production and purebred commercial herds are included.

2 Cross-bred beef cow-calf pasture systems (rotational crossing) producing their own replacement females but buying breeding bulls or their semen.

3 Cross-bred cow-calf pasture systems (terminal crossing) importing their female replacements from dairy or dual purpose cow herds or from herds of beef dam lines and buying beef bulls or their semen for terminal crossing.

4 Dairy or dual purpose milking herds which may apply terminal crossing with beef bulls to part of the herd; integrated fattening or selling of all cross-bred and excessive dairy progeny is assumed. Transfer of not-mated cross-bred heifers to Production System 3 is possible.

In PARA.TXT, the parameter file for program EWBC, values 1 to 3 are allowed. In the program EWDC, this parameter is always fixed to 4.

4.1.1.2 Crossing in the system (only for program EWDC)

Two variants are differentiated:

0 No crossbreeding in the system

1 Crossbreeding in the system

4.1.1.3 Variants for fattening (only for program EWBC - Production Systems 1 to 3)

0 No fattening at all

1 Intensive fattening of bulls, heifers or castrates

2 Intensive fattening of bulls, extensive fattening of heifers and castrates on pasture.

4.1.1.4 Variants for housing technology in fattening

1 Bind technology

2 Free technology

3 Pasture (only in program EWBC, not allowed in program EWDC)

4.1.1.5 Maturity type of progeny

In Production System 4, a differentiation is made between the maturity type of pure-bred and the maturity type of cross-bred progeny. Maturity type influences only the calculation of net energy and protein requirements for castrates and heifers in fattening.

1 Early (animals of small or middle body size of British or American breeds as Aberdeen Angus, Holstein and crosses between them)

2 Medium (breeds Hereford, Sussex and crosses between them as well as crosses between maturity types 1 and 3)

3 Late (animals of large body size of European breeds as Charolais, Limousin, Simmental and crosses between them)

4.1.1.6 Base conditions of the milk market (quota - program EWDC only)

1 Free market for milk and milk components (fat and protein)

2 Quota system for milk yield only

3 Quota system for milk yield and fat content

4.1.1.7 Parameters of the lactation curve

Both options work only in program EWBC (for Production Systems 1 to 3), the parameter is not needed in program EWDC (for Production System 4).

1 The values are read from input file INPUT20.TXT. This option should be used if the user of the program has sufficient information to estimate the parameters of the lactation curve directly. It is preferable to option 2.

2 The parameters are approximately estimated as described in Section 2.3.1. This option should be used when there is not enough information to estimate the parameters of the lactation curve directly.

4.1.1.8 Utilisation of pure-bred female dairy calves which are not needed for replacement (only in program EWDC - System 4)

The following options are available:

1 Selling of surplus reared female calves outside the systems (export)

2 Fattening of surplus reared female calves

3 Selling of surplus breeding heifers before mating

4 Selling of surplus pregnant breeding heifers

4.1.1.9 Utilisation of cross-bred female dairy x beef calves (only in program EWDC - System 4)

1 Selling of reared cross-bred female calves outside the systems (export)

2 Fattening of reared cross-bred female calves

3 Selling (transferring) of cross-bred (not-mated) heifers to the cow-calf Production System 3. **When choosing this option, you must first run EWBC with Production System 3 to generate the files FROM1_3.TXT and T.TXT.**

4 Combination of fattening and selling of cross-bred female calves

If choice 4 is made, the proportion of sold female calves has to be given (in input file INPUT23.TXT - see Section 4.3.7 on page 99)

4.1.1.10 Castrates in fattening (only in program EWDC - System 4)

The following options are available both for pure-bred and cross-bred castrates:

0 No castrates in fattening

1 Castrates in fattening

If there is no crossbreeding in the system the option for fattening cross-bred castrates is automatically set to 0. If castrates in fattening are assumed (option set to 1) and, on the basis of data in INPUT15.TXT, it comes out that there are no male calves available which can be castrated, the option is automatically set to zero and a warning is printed in the results file.

4.1.1.11 Calculation of feeding costs

1 Feeding costs are calculated on the basis of net energy content (expressed in MJ NE) and protein content (expressed in grammes protein digestible in intestine [protéines digestibles dans l'intestin] - PDI) in the feed rations.

2 Feeding costs are calculated on the basis of net energy content in the feed rations (expressed in MJ NE); protein content in feed in PDI units is not available.

4.1.1.12 Mating type (only in program EWBC - for Production Systems 1 to 3)

Mating type occurs twice in the input file PARA.TXT (for heifers and for cows - see Section 4.1.2). The options which are allowed for are equal for both categories of animals (you can choose different options for heifers and cows):

1 Artificial insemination is used at least in the first oestrus within one mating period.

2 Natural mating is used throughout.

4.1.1.13 Selection group for which gene flow is calculated

Gene flow can be calculated for both sexes. The options for Systems 1 to 3 (program EWBC) are:

1 Beef sires.

2 Beef dams.

In System 4 (program EWDC), there are three options:

1 Dairy sires.

2 Dairy dams.

3 Beef sires.

More information on gene flow is given in Section 2.8 and in the papers cited there.

4.1.1.14 Options for the calculation of economic weights in program EWDC (System 4)

0 Economic weights are calculated only for traits expressed in pure-bred dairy progeny (when no terminal crossing is used).

1 Economic weights are calculated only for traits expressed in cross-bred progeny (when only economic weights for beef cattle are of interest).

2 Economic weights are calculated for traits both expressed in pure-bred and cross-bred progeny (when economic weights for dairy cattle are of interest and terminal crossing in dairy herds is used).

If there is no cross-breeding in the system, this parameter is automatically set to 0 in the program.

4.1.1.15 Options for the calculation of the milk price in program EWDC (System 4)

1 The milk price does not depend neither on the somatic cell count nor on other factors (protein content, fat content, rennet coagulation time, curd firmness).

2 The milk price depends only on somatic cell count.

3 The milk price does not depend on SCC, but depends on one to four of the following factors: protein content, fat content, rennet coagulation time and curd firmness.

4 The milk price depends on both somatic cell count (SCC) and on one to four of the following factors: protein content, fat content, rennet coagulation time and curd firmness. The base prices for quality classes according to SCC are set first and then these prices are corrected for the further factors.

5 The milk price depends on both somatic cell count (SCC) and on one to four of the following factors: protein content, fat content, rennet coagulation time and curd firmness. The base price for milk (milk carrier or milk with given fat and/or protein content and/or milk coagulation properties) is determined first. Then this price is corrected for the real values of at least one of the following four factors: protein content, fat content, rennet coagulation time and curd firmness. At the last step, a further correction of the price for milk quality classes based on SCC is carried out.

4.1.1.16 Options for milk coagulation properties, mastitis, claw disease (only in program EWDC - System 4) and residual feed intake of different categories of animals (both in programs EWBC and EWDC)

There are only two options for the traits rennet coagulation time, curd firmness, mastitis incidence, claw disease and residual feed intake of different categories of animals:

0 Data are not available or are not of interest.

1 Data are of interest and are available.

4.1.1.17 Options for reading genetic standard deviations of traits

The following options are possible for genetic standard deviation of the traits:

1 Genetic standard deviations are not known or are not intended to be used for the calculation of relative economic weights.

2 Genetic standard deviations are known for the direct and maternal components of the traits and given in INPUT35.TXT or INPUT32.TXT for programs EWBC or EWDC, respectively. In EWBC, this option must not be used for Production System 3.

3 Genetic standard deviations are not differentiated between direct and maternal components and given in INPUT36.TXT or INPUT33.TXT for programs EWBC or EWDC, respectively. In EWDC, this option makes only sense if there is no crossbreeding in the production system.

4.1.2 Parameter file PARA.TXT for Production Systems 1 to 3 (program EWBC)

An example of the file is:

```
"Between these two quotation marks you can write any comment which helps you to
identify the results"[1]
1
"Production System
  (1 Closed purebred ...
   2 Closed crossbred ...
   3 Open beef x dairy ...)"
1
"Fattening
   (...)"
2
"Housing technology in fattening
   (...)"
3
"Maturity type of progeny
   (...)"
2
"Way of calculating parameters for lactation curve
   (...)"
1
"Way of calculating feed cost
   (...)"
1
"Mating type for heifers
   (...)"
1
"Mating type for cows
   (...)"
2
"Sex for which gene flow is calculated
```

[1] The text between the two quotation marks at the beginning of the file will be printed as it is to the results file.

```
   (...)"
20
"Number of reproductive cycles (...  )"
3
“Genetic standard deviations of the traits
   (...)”
1
"Calculation of economic value for residual dry matter intake of heifers in
   rearing (...)"
0
"Calculation of economic value for residual dry matter intake of animals in
   fattening (...)"
1
"Calculation of economic value for residual dry matter intake of adult animals
   (...)"
```

There are certain dependencies between the parameters in the parameter file and further parameters in the data input files which must be taken into account. The following paragraphs list these dependencies.

4.1.2.1 Consequences of changing the parameter 'Number of reproductive cycles'

The length of vectors referring to the 'Number of reproductive cycles' in files INPUT02.TXT and INPUT26.TXT must be changed. When changing the number of reproductive cycles and calculating Production System 3 with the intention to use the results in program EWDC, change the parameter 'Number of age classes for cross-bred dams' in input file INPUT27.TXT for program EWDC. This parameter is calculated as Number of reproductive cycles in System 3 + age at calving in years - 1.

4.1.2.2 Consequences of changing the parameter 'Fattening'

The last five input parameters in INPUT03.TXT and the parameters 'Pregnant heifers sold expressed as proportion of surplus female calves' and 'Breeding heifers sold before mating expressed as proportion of surplus female calves' must be in accordance with the parameter 'Fattening' in PARA.TXT.

4.1.3 Parameter file PARAD.TXT for Production System 4 (program EWDC)

An example of the parameter file for program EWDC is:

```
"Between these two quotation marks you can write any comment which helps you to
identify the results"[2]
1
   "Crossbreeding in the system
   (0 No crossbreeding used
   1 Crossbreeding used)"
2
"Housing technology in fattening
   (...)"
3
"Housing technology in cow herds
   (...)"
```

[2] The text between the two quotation marks at the beginning of the file will be printed as it is to the results file.

```
3
"Maturity type of pure-bred progeny
   (...)"
2
"Maturity type of cross-bred progeny
   (...)"
2
"Utilisation of pure-bred female calves which are not needed for replacement
   (...)"
3
"Utilisation of cross-bred female calves which are not needed for replacement
   (...)"
0
“Pure-bred castrates in fattening
   (...)"
0
“Cross-bred castrates in fattening
   (...)"
1
"Way of calculating feed cost
   (...)"
2
"Option for calculating economic weights
   (0 Economic weights are calculated only for traits expressed in
      pure-bred dairy progeny (when no terminal crossing is used)
    1 Economic weights are calculated only for traits expressed in
      cross-bred progeny (when only economic weights for beef cattle
      are of interest)
    2 Economic weight are calculated for traits both expressed in
      pure-bred and cross-bred progeny (when economic weights for
      dairy cattle are of interest and terminal crossing in dairy
      herds is used))"
1
"Selection group for which gene flow is calculated
   (...)"
1
"Data for mastitis incidence
   (0 are not available
    1 are available)
3
"Quota for milk market
   (...)"
1
"Option for the calculation of the milk price
   (...)"
1
"Data for curd firmness
   (...)"
1
"Data for rennet coagulation time
   (...)"
10
"Number of reproductive cycles (should be in the range from 4 to 15)"
2
"Genetic standard deviation of the traits
   (1:  are not known or are not intended to be used for the calculation of
    relative economic weights
    2:   are known for the direct and maternal components of the traits and
```

```
    given in INPUT32.TXT
    3:   are not differentiated between direct and maternal components and
    given in INPUT33.TXT)"
1
"Data for claw disease incidence
   (0 are not available or not of interest
    1 are of interest and are available )"
1
"Calculation of economic value for residual dry matter intake of calves in
   rearing
   (0:  no
    1:  yes)."
1
"Calculation of economic value for residual dry matter intake of heifers in
   rearing
   (0:  no
    1:  yes)."
0
"Calculation of economic value for residual dry matter intake of animals in
   fattening
   (0:  no
    1:  yes)."
1
"Calculation of economic value for residual dry matter intake of cows
   (0:  no
    1:  yes)."
```

As stated above for PARA.TXT, there are also certain dependencies between the parameters in the parameter file PARAD.TXT and further parameters in the data input files which must be taken into account. The following paragraphs list some important dependencies.

4.1.3.1 Consequences of changing the parameter 'Crossbreeding' in the system

If there is no crossbreeding in the system ($cb = 0$), the option for calculating economic weights is automatically set to zero ($ewopt = 0$) independent of the value given in PARAD.TXT. Furthermore, the proportion of dairy cows in reproductive cycle $i + 1$ ($i = 0, ..., LL - 2$) mated with beef bulls ($pcross[i]$, read from INPUT07.TXT) and the proportion of dairy heifers mated with beef bulls ($pcrossh$, read from INPUT11.TXT) will be automatically set to zero. In input file INPUT27.TXT, the number of age classes for beef sires ($acsb$) and the number of age classes for cross-bred dams ($acdc$) must be both zero for systems without crossbreeding, otherwise an error message will occur when running the program and the program will stop.

4.1.3.2 Consequence of changing the parameter 'Utilisation of cross-bred female calves'

If this option takes the value 4, check the input parameter 'Sold cross-bred female calves as proportion of reared cross-bred female calves' in input file INPUT15.TXT to be in accordance with the given option.

4.1.3.3 Consequence of changing the parameter 'Option for calculating economic weights'

In the file PARAD.TXT, the 'Selection group for which gene flow is calculated' must be in agreement with the option for calculating economic weights.

4.1.3.4 Consequence of changing the parameter 'Selection group for which gene flow is calculated'

This parameter must be in accordance with the 'Option for calculating economic weight' in PARAD.TXT.

4.1.3.5 Consequences of changing the parameter 'Data for mastitis incidence'

For option 1 of this parameter, data from input files INPUT29.TXT and INPUT30.TXT must be available. If option zero is used, these two files are not read and you need not care about the values given in these files.

4.1.3.6 Consequences of changing the parameter 'Number of reproductive cycles'

When changing the number of lactations (reproductive cycles) take care to change all other input parameters in the appropriate way, especially in INPUT07.TXT, INPUT27.TXT, INPUT29.TXT and INPUT37.TXT.

4.2 Data input files for program EWBC (Production Systems 1 to 3)

A survey of data input files for Production Systems 1 to 3 is given in Table 4.1. Input files for Production Systems 1 to 3 are needed for running the program EWBC, input files for Production System 4 are needed for running the program EWDC. The latter are treated with in the following Section 4.3. At the beginning of each input file a comment is placed starting with /* and ending with */. The program recognises the slash (/) as the beginning and the end of the comment. When changing this text, do not use slashes within the comment (stars can be used within the comment).

For each input, the names of variables as they are used in the programs are given in parentheses.

4.2.1 Input file INPUT01.TXT

This file is necessary for Production Systems 1 to 3, the last parameter only for Production System 1. It includes input parameters describing the reproductive cycle in pasture systems through a year. All dates are given as two numbers (month, day) separated by one blank (or more blanks).

The following parameters are read from this file:

- Date of beginning pasture (*dbpas*)
- Date of ending pasture (*depas*)
- Date of starting the mating period (*dsmp*)
- Date of ending the first part of the mating period covering the first possibility of a female to conceive (*deai*, previous date + approximately 20 days)
- Date of starting the second part of the mating period (*dsnm*2)
- Date of ending the second part the mating period covering the second possibility of females to conceive (*denm*2, previous date + approximately 20 days)
- Date of starting the third part of the mating period (*dsnm*3)

Table 4.1: Survey of data input files for program EWBC (Production Systems [PS] 1 to 3)

Input file	PS1	PS2	PS3	Remark
INPUT01.TXT	x	x	x	
INPUT02.TXT	x	x	x	
INPUT03.TXT	x	x	x	
INPUT04.TXT	x	x	x	
INPUT05.TXT	x			
INPUT06.TXT	x	x	x	
INPUT08.TXT	x	x	x	
INPUT09.TXT	x	x	x	only for variant 2 of fattening (see Section 4.1.1.3)
INPUT10.TXT	x	x	x	only for variant 1 of fattening (see Section 4.1.1.3)
INPUT13.TXT	x	x		
INPUT14.TXT			x	
INPUT16.TXT	x	x	x	
INPUT17.TXT	x	x	x	only for variant 1 of fattening (see Section 4.1.1.3)
INPUT18.TXT	x	x	x	only for variant 2 of fattening (see Section 4.1.1.3)
INPUT19.TXT	x	x	x	only if the parameters of the lactation curve are calculated by the program (see Section 4.1.1.7)
INPUT20.TXT	x	x	x	only if the parameters of the lactation curve are read in (see Section 4.1.1.7)
INPUT26.TXT	x	x	x	
INPUT34.TXT	x	x	x	
INPUT35.TXT	x	x	x	only if relative economic weights are calculated
INPUT36.TXT	x	x	x	only if relative marginal economic values are calculated

- Date of ending the third part of the mating period (end of the mating period) covering the third possibility of females to conceive ($denm3$, previous date + approximately 20 days)
- Date of weaning calves ($dw0$)
- Starting date for the test of bulls (*startbt*, only needed for Production System 1)

4.2.2 Input file INPUT02.TXT

This file is necessary for Production Systems 1 to 3. It includes input parameters describing reproductive cycles of the cow herd in pasture systems. For each reproductive cycle, cows entering this cycle are differentiated in pregnant cows and cows not being pregnant. Losses of cows, culling etc. can be different in both groups. Two groups of cows are differentiated according to calving performance: cows with easy calving and cows with dystocia. Input parameters for losses of cows and calves, for insemination etc. can differ in both groups. The length of the vector (number of elements in the vector) is given by the number of reproductive cycles LL. Be careful when inserting the values, because the index may run from 1 to LL, from 2 to LL, from 1 to $LL-1$, from 2 to $LL-1$ etc. The first 2 inputs are no vectors but simple numbers.

Two groups of calf losses at calving are differentiated here: stillborn calves (12th and 13rd inputs) and calves died till 48 hours after birth (14th and 15th inputs). If only one summary statistics exist for calf losses at birth which include all calves died till a certain time after birth, insert these data in the vectors for stillborn calves and put only zeros in the vectors for calves died to 48 hours after birth.

Some of the probabilities of calving score at the end of the input file may be of no concern. For example, if the number of classes for calving performance is 4, all values for calving scores 5 and 6 are ignored. Do not delete rows with unnecessary information in the input file. The program will skip the inputs which are not needed.

The following parameters are read from this file:

- Number of classes for calving score (DD)
- For defining dystocia give the lowest score of calving performance which is considered to be dystocia (*dyscl*). For example, if there are scores 1 to 5 and scores 3 to 5 will be considered as dystocia your input will be 3.
- Vector of cow losses within reproductive cycles 1 to LL as proportion of cows entered the reproductive cycle as pregnant cows ($pp[25+i*6]$)
- Vector of cow losses within reproductive cycles 2 to LL as proportion of cows entered the reproductive cycle as barren cows ($np[25+i*6]$)
- Vector of cows culled within reproductive cycles 1 to LL for health problems other than dystocia as proportion of cows which entered these cycles as pregnant cows ($pp[27+i*6]$). Cows culled for failure to conceive must not be included.
- Vector of cows culled within reproductive cycles 2 to LL for health problems other than dystocia as proportion of cows which entered these cycles as barren cows ($np[27+i*6]$). Cows culled for failure to conceive must not be included.
- Vector of barren cows which stayed in the herd for the next mating period as proportion of all barren cows in reproductive cycles 1 to $LL-1$ that entered these cycles as pregnant cows ($npcsp[i]$)

- Vector of barren cows which stayed in the herd for the next mating period as proportion of all barren cows in reproductive cycles 2 to $LL-1$ that entered these cycles as barren cows ($npcsn[i]$)
- Vector of cows having dystocia that were inseminated in 1st oestrus within reproductive cycles 1 to $LL-1$, respectively, as proportion of all mated cows having dystocia in these cycles[3] ($pinmatd[i]$)
- Vector of cows without dystocia that were inseminated in 1st oestrus within reproductive cycles 1 to $LL-1$ as proportion of all mated cows not having dystocia in these cycles ($pinmatnd[i]$)
- Vector of probabilities of abortion[4] for cows conceived in reproductive cycles 1 to LL ($ab[i]$)
- Vector of still-born calves after dystocia as proportion of cows having dystocia in reproductive cycles 1 to LL ($stcd[i]$)
- Vector of still-born calves after easy calving as proportion of cows having easy calving in reproductive cycles 1 to LL ($stce[i]$)
- Vector of calves died to 48 hours as proportion of calves born alive after dystocia in reproductive cycles 1 to LL ($dcd[i]$)
- Vector of calves died to 48 hours as proportion of calves born alive after easy calving in reproductive cycles 1 to LL ($dce[i]$)
- Vector of probabilities of calving score 2 when female is born in reproductive cycles 1 to LL ($dysff[1][i]$)
- Vector of probabilities of calving score 3 when female is born in reproductive cycles 1 to LL ($dysff[2][i]$)
- Vector of probabilities of calving score 4 when female is born in reproductive cycles 1 to LL ($dysff[3][i]$)
- Vector of probabilities of calving score 5 when female is born in reproductive cycles 1 to LL ($dysff[4][i]$)
- Vector of probabilities of calving score 6 when female is born in reproductive cycles 1 to LL ($dysff[5][i]$)
- Vector of probabilities of calving score 2 when male is born in reproductive cycles 1 to LL ($dysmm[1][i]$)
- Vector of probabilities of calving score 3 when male is born in reproductive cycles 1 to LL ($dysmm[2][i]$)
- Vector of probabilities of calving score 4 when male is born in reproductive cycles 1 to LL ($dysmm[3][i]$)
- Vector of probabilities of calving score 5 when male is born in reproductive cycles 1 to LL ($dysmm[4][i]$)
- Vector of probabilities of calving score 6 when male is born in reproductive cycles 1 to LL ($dysmm[5][i]$)

[3] This and the following vector are not read if only natural mating is used.
[4] It is assumed that cows have lactation after abortion.

4.2.3 Input file INPUT03.TXT

This file is necessary for Production Systems 1 to 3. It includes input parameters describing cows and heifers in pasture systems.

Some of the inputs referring to calving score may be of no concern. For example, if the number of classes for calving performance is 4, all values for calving scores 5 and 6 are ignored. Do not omit rows with unnecessary information in the input file. The program will skip the inputs which are not needed.

The following parameters are read from this file:

- Conception rate of heifers in the 1st oestrus during the first part of the mating period expressed as proportion of heifers mated in this oestrus ($crinh$)
- Conception rate of heifers in the 2nd oestrus during the second part of the mating period expressed as proportion of heifers not being pregnant after the 1st oestrus ($cr2nmh$)
- Conception rate of heifers in the 3rd oestrus during the third part of the mating period expressed as proportion of heifers not being pregnant after the 2nd oestrus ($cr3nmh$)
- Conception rate of cows in the 1st oestrus during the first part of the mating period for cows not having dystocia in reproductive cycles 1 to $LL-1$ expressed as proportion of cows mated in this oestrus ($ecrinc$)
- Conception rate of cows in the 2nd oestrus during the second part of the mating period for cows not having dystocia in reproductive cycles 1 to $LL-1$ expressed as proportion of cows not being pregnant after the 1st oestrus ($ecr2nmc$)
- Conception rate of cows in the 3rd oestrus during the third part of the mating period for cows not having dystocia in reproductive cycles 1 to $LL-1$ expressed as proportion of cows not being pregnant after the 2nd oestrus ($ecr3nmc$)
- Length of pregnancy ($lgpre$)
- Average decrease in conception rate of cows after having dystocia in reproductive cycles 1 to LL ($crdys$)
- Number of cows per bull for natural mating ($cowb$)
- Number of re-inseminations per oestrus (nr)
- Average length of the interval between calving and the beginning of the mating period ($intcm$)
- Fat content in milk (fat)
- Protein content in milk ($prot$)
- Cow weight after second calving ($wcacal[1]$)
- Mature weight of cows (= cow weight after 3rd calving, mcw)
- Weight gain for pregnancy (= loss of cow weight after calving) in reproductive cycles 1 to LL ($wpreg$)
- Dressing proportion of cows ($drescw$)

- Culling rate of cows after dystocia averaged over reproductive cycles 1 to LL (cmd)
- Losses of calves from 48 hours after calving to weaning averaged over reproductive cycles and sexes (dcw)
- Losses of feed through wasting in winter feeding ($loswf$)
- Losses of feed through wasting on pasture ($losfpa$)
- Amount of dry matter produced per ha pasture ($dryhayha$)
- Dry matter per kg summer feed ration for suckling calves (without milk) ($drys$[8])
- Dry matter per kg winter feed ration for suckling calves (without milk) ($dryw$[8])
- Dry matter per kg summer feed ration for cows ($drys$[25])
- Dry matter per kg winter feed ration for cows ($dryw$[25])
- Residual dry matter intake of cows in summer period ($rfis$[25])
- Residual dry matter intake of cows in winter period ($rfiw$[25])
- Net energy per kg dry matter of summer feed ration for cows (eds[25])
- Net energy per kg dry matter of summer feed ration (without milk) for suckling calves (eds[8])
- Net energy per kg dry matter of winter feed ration for cows (edw[25])
- Net energy per kg dry matter of winter feed ration (without milk) for suckling calves (edw[8])
- Protein per kg dry matter of summer feed ration for cows ($pdids$[25])
- Protein per kg dry matter of summer feed ration (without milk) for suckling calves ($pdids$[8])
- Protein per kg dry matter of winter feed ration for cows ($pdidw$[25])
- Protein per kg dry matter of winter feed ration (without milk) for suckling calves ($pdidw$[8])
- Adjustment factor for breed energy requirement for maintenance - dry cows[5] (kbd)
- Adjustment factor for breed energy requirement for maintenance - lactating cows (kbl)
- Adjustment factor for energy requirement for maintenance according to technology - pasture (ktp)
- Adjustment factor for energy requirement for maintenance according to technology - bind technology (ktb)
- Adjustment factor for energy requirement for maintenance according to technology - free technology (ktf)

[5] The values for this and the following four adjustment factors used in the example files were taken from [5].

- Amount of minerals per cow (including calf) and day (min[25])
- Amount of water per cow (including calf) and day (wat[25])
- Amount of straw per cow (including calf) and day during winter housing ($straw$[30])
- Amount of dung per cow (including calf) and day during winter housing ($dung$[30])
- Price per portion of semen for AI ($prai$)
- Price per re-insemination ($prair$)
- Price per kg fresh matter of winter feed ration for cows (prw[25])
- Price per kg fresh matter of winter feed ration for suckling calves (without milk) (prw[8])
- Price per kg fresh matter of summer feed ration for cows (prs[25])
- Price per kg fresh matter of summer feed ration for suckling calves (without milk) (prs[8])
- Price per kg dung ($prdg$)
- Price per kg minerals for cows (prm[25])
- Price per kg minerals for replacement heifers (prm[22])
- Price per kg straw ($prst$)
- Price per l water ($prwt$)
- Price for sold female weaned calves (per kg live weight) (pr[8])
- Price for sold male weaned calves (per kg live weight) (pr[9])
- Price per kg carcass of cows in the base class for fleshiness and fat covering[6] (prc)
- Ratio of price per kg carcass of cows involuntarily culled to the price per kg carcass of cows voluntarily culled (kpr[29])
- Governmental financial support per weaned calf ($dotcalf$)
- Governmental financial support per performance-tested cow and year ($dotcowh$)
- Additional governmental financial support per cow and year ($dotcowo$)
- Governmental financial support per culled cow ($dotcows$)
- Governmental financial support per exported male calf ($dotexpm$)
- Fraction of performance-tested cows ($herdbook$)
- Cost for removing and rendering a dead cow ($costdc$)
- Cost for removing and rendering a dead young animal ($costdf$)

[6] The "base" class will mostly but not necessarily be the best class. The prices for all other classes are then calculated by multiplying the price of the base class with a coefficient. These coefficients will be given in the input file INPUT16.TXT on page 83. The price coefficient for the "base" class or "reference" class is naturally 1.

- Cost for veterinary treatment per cow and reproductive cycle (including calf to weaning) ($costv[30]$)
- Veterinary cost connected with calving score 1 ($vetdys[0]$)
- Veterinary cost connected with calving score 2 ($vetdys[1]$)
- Veterinary cost connected with calving score 3 ($vetdys[2]$)
- Veterinary cost connected with calving score 4 ($vetdys[3]$)
- Veterinary cost connected with calving score 5 ($vetdys[4]$)
- Veterinary cost connected with calving score 6 ($vetdys[5]$)
- Stock-man hours connected with calving score 1 ($labdys[0]$)
- Stock-man hours connected with calving score 2 ($labdys[1]$)
- Stock-man hours connected with calving score 3 ($labdys[2]$)
- Stock-man hours connected with calving score 4 ($labdys[3]$)
- Stock-man hours connected with calving score 5 ($labdys[4]$)
- Stock-man hours connected with calving score 6 ($labdys[5]$)
- Cost per stock-man hour (needed for dystocia cost) ($costlab$)
- Fixed cost per cow and day (including calf to weaning) ($fixcc$)
- Discount rate (u)
- Barren heifers culled after their 1st mating period expressed as proportion of heifers not conceiving in their 1st mating period ($hcmat1$)
- Barren heifers culled after their 2nd mating period expressed as proportion of heifers not conceiving in their 2nd mating period ($hcmat2$)
- Female calves sold at weaning expressed as proportion of surplus female calves[7] ($exfc$)
- Male calves sold at weaning expressed as proportion of male weaned calves[8] ($exmc$)
- Proportion of weaned male calves which are performance tested ($mtest$). This input is read only for Production System 1.
- Fattened castrates expressed as proportion of male calves determined for fattening ($pcmf$)
- Proportion of surplus female calves for fattening[9] (pff)

[7] In systems 1 and 2, the sum of the following input parameters must be one: Female calves sold expressed as proportion of surplus female calves, female calves for fattening expressed as proportion of surplus female calves (both in INPUT03.TXT), pregnant heifers sold expressed as proportion of surplus female calves (INPUT13.TXT) and breeding heifers sold before mating expressed as proportion of surplus female calves (INPUT13.TXT). In system 3, the first two parameters must sum to one. The remaining two parameters are ignored.

[8] If there is no fattening of male calves, this parameter must be 1 (in Systems 2 and 3) or must sum up to 1 with the following parameter in System 1.

[9] See footnote 7.

4.2.4 Input file INPUT04.TXT

This file is necessary for Production Systems 1 to 3 if natural mating is performed. It includes input parameters referring to breeding bulls kept in the cow herd for natural mating. The first two numbers in the file are ignored in Production System 1.

The following parameters are read from this file:

- Age of breeding bulls at purchase for the herd (*agebbse*, only for Systems 2 and 3)
- Weight of breeding bulls at purchase for the herd (*wbbse*, only for Systems 2 and 3)
- Productive lifetime of breeding bulls in numbers of reproductive cycles of cows ($lifebb$)
- Age of breeding bulls at reaching mature body weight (*agebbm*)
- Dry matter per kg summer feed ration for breeding bulls in the herd ($drys[10]$)
- Dry matter per kg winter feed ration for breeding bulls in the herd ($dryw[10]$)
- Residual dry matter intake of breeding bulls in summer period[10] ($rfis[10]$)
- Residual dry matter intake of breeding bulls in winter period ($rfiw[10]$)
- Net energy content per kg dry matter of summer feed ration for breeding bulls in the herd ($eds[10]$)
- Net energy content per kg dry matter of winter feed ration for breeding bulls in the herd ($edw[10]$)
- Protein content per kg dry matter of summer feed ration for breeding bulls in the herd ($pdids[10]$)
- Protein content per kg dry matter of winter feed ration for breeding bulls in the herd ($pdidw[10]$)
- Price per kg fresh matter of winter feed ration for breeding bulls in the herd ($prw[10]$)
- Price per kg fresh matter of summer feed ration for breeding bulls in the herd ($prs[10]$)
- Amount of minerals per day and breeding bull ($min[10]$)
- Price per kg minerals for breeding bulls ($prm[10]$)
- Amount of straw per breeding bull in the herd in winter housing per day (*strawbb*)
- Amount of dung per breeding bull in the herd in winter housing per day (*dungbb*)
- Amount of water per day and breeding bull ($wat[10]$)
- Average price per breeding bull purchased for natural mating (*prbb*)

[10] This and the following input are read only if the economic weight for residual feed intake for adult animals is calculated.

- Cost for veterinary treatment per breeding bull in the herd per reproductive cycle (*costvbb*)
- Fixed cost per breeding bull in the herd per day ($fixcbb$)
- Average price per kg carcass weight of culled (old) breeding bulls (*prbbcull*)

4.2.5 Input file INPUT05.TXT

This file is necessary only for Production System 1. It includes input parameters referring to performance tested breeding bulls. The feed rations as well as other costs refer to three time periods. The first period is before the test when the weaned calves are getting used to the intensive feed ration. The second period is the test with a fixed length, and the third period, in which the exterior and sperm quality is proved, is from the test end to the time of selecting and selling bulls.

The following parameters are read from this file:

- Daily gain of bulls in test (*adgbbt*)
- Length of the test (*lengbt*)
- Days from the end of the test to selling bulls (*dtse*)
- Bulls selected as proportion of bulls tested at station (*msel*)
- Price per kg fresh matter of feed ration for breeding bulls before test (*prtb*)
- Price per kg fresh matter of feed ration for breeding bulls in test (*prt*)
- Price per kg fresh matter of feed ration for breeding bulls after test (*prtse*)
- Protein content per kg dry matter of feed ration for breeding bulls before test (*pdidtb*)
- Protein content per kg dry matter of feed ration for breeding bulls in test (*pdidt*)
- Protein content per kg dry matter of winter feed ration for breeding bulls after test (*pdidtse*)
- Net energy content per kg dry matter of feed ration for breeding bulls before test (*edtb*)
- Net energy content per kg dry matter of feed ration for breeding bulls in test (*edt*)
- Net energy content per kg dry matter of feed ration for breeding bulls after test (*edtse*)
- Dry matter per kg feed ration for breeding bulls before test (*drytb*)
- Dry matter per kg feed ration for breeding bulls in test (*dryt*)
- Dry matter per kg feed ration for breeding bulls after test (*drytse*)
- Residual dry matter intake of breeding bulls before test[11] ($rfitb$)
- Residual dry matter intake of breeding bulls in test ($rfit$)

[11] This and the following two inputs are only read if the economic value for residual dry matter intake in intensive fattening is to be calculated.

- Residual dry matter intake of breeding bulls after test ($rfits$)
- Amount of dung per breeding bull at station per day ($dung$[10])
- Amount of straw per breeding bull at station per day ($straw$[10])
- Cost for veterinary treatment per bull at test station till selling ($costv$[10])
- Fixed costs per breeding bull on test station per day ($fixcbt$)
- Governmental support per bull on test station per day ($dottest$)
- Average price for selected bulls at selling ($prbbsel$)

4.2.6 Input file INPUT06.TXT

This file is necessary for Production Systems 1 to 3. It includes input parameters mainly connected with the progeny testing system for beef bulls. If there are only two weighings available, see the remark to INPUT06.TXT in Subsection 2.6.1 for a proposal how to proceed.

The following parameters are read from this file:

- Birth weight of female calves (bwf)
- Birth weight of male calves (bwm)
- Age of calves at first weighing (first control) (con_1)
- Weight of female calves at first weighing ($w1conf$)
- Weight of male calves at first weighing ($w1conm$)
- Age of calves at second weighing (second control) (con_2)
- Weight of female calves at second weighing ($w2conf$)
- Weight of male calves at second weighing ($w2conm$)
- Age of calves at third weighing (third control) (con_3)
- Weight of female calves at third weighing ($w3conf$)
- Weight of male calves at third weighing ($w3conm$)
- Mature weight of bulls used in the herd (mwb)

4.2.7 Input file INPUT08.TXT

This file is necessary for Production Systems 1 to 3. It includes input parameters valid for both variants of fattening. Furthermore, this file covers parameters for fattening bulls that are expected to be always intensively fattened independently of the variant for fattening for heifers or castrates.

Even if there is no fattening in the system, some input parameters are needed for culled breeding animals.

Losses of animals are given as number of animals died[12] during the fattening period expressed as proportion of the number of animals that entered fattening. Dressing percentage is expressed as ratio of the carcass weight and live weight of animals at slaughter.

[12] For simplicity of the calculation, it is assumed that animals died in the middle of the time period under consideration. The same was assumed for animals slaughtered for health problems.

If all surplus weaned calves are sold, the parameters connected exclusively with fattening are ignored in the calculations. But some of the parameters (as dressing proportion, price for slaughter animals, number of classes for fleshiness and fat covering) will be needed in each calculation, as there will be always culled heifers and bulls in the herd.

The following parameters are read from this file:

- Daily gain of bulls in intensive fattening ($adgwsm$)
- Live weight of bulls at slaughter in intensive fattening ($wbfat$)
- Dressing proportion of bulls ($dresb$)
- Dressing proportion of castrates ($dresc$)
- Dressing proportion of heifers ($dresh$)
- Dressing proportion of bulls not reaching target slaughter weight as proportion of dressing proportion of bulls reaching slaughter weight ($kdresb$)
- Number of fattened bulls slaughtered before reaching target slaughter weight expressed as proportion of the total number of fattened bulls ($nmcf$)
- Losses of bulls in intensive fattening ($dmcf$)
- Amount of water per animal and day in intensive fattening of bulls (wat[14])
- Amount of dung per animal and day in intensive fattening ($dungfi$)
- Amount of straw per animal and day in intensive fattening ($strawfi$)
- Dry matter per kg feed ration for fattened bulls ($dryf$[14])
- Average residual daily dry matter intake of fattened bulls (rfi[14])
- Net energy content per kg dry matter of feed ration for fattened bulls (edf[14])
- Protein content per kg dry matter of feed ration for fattened bulls ($pdidf$[14])
- Price per kg fresh matter of feed ration for fattened bulls (prf[14])
- Losses of feed through wasting in intensive fattening and in the test of bulls ($losff$)
- Price per kg carcass of bulls in the base class[13] (prb)
- Coefficient for price decrease for bulls involuntarily culled in fattening (ratio between the price per kg carcass of involuntarily culled bulls and the price per kg carcass of bulls that reached target slaughter weight, kpr[14])
- Cost for veterinary treatment per animal in intensive fattening ($costvfi$)
- Fixed cost per animal and day in intensive fattening ($fixcfi$)
- Number of classes for fleshiness(maximum 20) ($p1$)
- Number of classes for fat covering(maximum 20) ($p2$)
- Governmental support per fattened bull ($dotfatib$)

[13] The "base" class will mostly but not necessarily be the best class. The prices for all other classes are then calculated by multiplying the price of the base class with a coefficient. These coefficients will be given in the input file INPUT16.TXT on page 83. The price coefficient for the "base" class or "reference" class is naturally 1.

4.2.8 Input file INPUT09.TXT

This file is necessary only for extensive fattening (variant 2 for fattening - see Section 4.1.1.3) of heifers and castrates in Production Systems 1 to 3. If no castrates are fattened the input parameters referring to castrates will be ignored by the program.

Three time periods are differentiated in fattening. The first period is the winter feeding period after weaning, the second one is summer feeding usually only on pasture, and the third period is an intensive feeding period after pasture. The third period is needed only if the animals do not reach the required slaughter weight at the end of the pasture period.

Losses of animals are defined as animals died[14] during the fattening period as proportion of all animals entering fattening.

The following parameters are read from this file:

- Daily gain of castrates in the winter period after weaning in extensive fattening ($dgcxw$)
- Daily gain of castrates in the summer period on pasture ($dgcxs$)
- Daily gain of castrates in the intensive fattening period after pasture ($dgcxas$)
- Daily gain of heifers in the winter period after weaning in extensive fattening ($dgfxw$)
- Daily gain of heifers in the summer period on pasture ($dgfxs$)
- Daily gain of heifers in the intensive fattening period after pasture ($dgfxas$)
- Live weight of castrates at slaughter in extensive fattening ($wcxfat$)
- Live weight of heifers at slaughter in extensive fattening ($whxfat$)
- Dressing proportion of castrates not reaching the target slaughter weight as proportion of the dressing proportion of castrates reaching the target slaughter weight ($kdresc$)
- Dressing proportion of heifers not reaching the target slaughter weight as proportion of the dressing proportion of heifers reaching the target slaughter weight ($kdresh$)
- Fattened castrates slaughtered before reaching the target slaughter weight expressed as proportion of all extensively fattened castrates ($nccf$)
- Fattened heifers slaughtered before reaching the target slaughter weight expressed as proportion of all extensively fattened heifers ($nfcf$)
- Losses of castrates in extensive fattening ($dccf$)
- Losses of heifers in extensive fattening ($dfcf$)
- Dry matter per kg feed ration for fattening castrates after pasture ($dryfx$[17])
- Dry matter per kg feed ration for fattening heifers after pasture ($dryfx$[12])
- Dry matter per kg winter feed ration (first winter after weaning) for extensively fattened castrates ($dryw$[17])
- Dry matter per kg winter feed ration (first winter after weaning) for extensively fattened heifers ($dryw$[12])

[14] see footnote 12 on page 74

- Dry matter per kg summer feed ration for extensively fattened castrates ($drys$[17])
- Dry matter per kg summer feed ration for extensively fattened heifers ($drys$[12])
- Net energy content per kg dry matter of feed ration for fattened castrates after pasture ($edfx$[17])
- Net energy content per kg dry matter of feed ration for fattened heifers after pasture ($edfx$[12])
- Net energy content per kg dry matter of summer feed ration for extensively fattened castrates (eds[17])
- Net energy content per kg dry matter of summer feed ration for extensively fattened heifers (eds[12])
- Net energy content per kg dry matter of winter feed ration for extensively fattened castrates (edw[17])
- Net energy content per kg dry matter of winter feed ration for extensively fattened heifers (edw[12])
- Protein content per kg dry matter of feed ration for fattened castrates after pasture ($pdidfx$[17])
- Protein content per kg dry matter of feed ration for fattened heifers after pasture ($pdidfx$[12])
- Protein content per kg dry matter of summer feed ration for extensively fattened castrates ($pdids$[17])
- Protein content per kg dry matter of summer feed ration for extensively fattened heifers ($pdids$[12])
- Protein content per kg dry matter of winter feed ration for extensively fattened castrates ($pdidw$[17])
- Protein content per kg dry matter of winter feed ration for extensively fattened heifers ($pdidw$[12])
- Price per kg fresh matter of feed ration for fattened castrates after pasture ($pras$[17])
- Price per kg fresh matter of feed ration for fattened heifers after pasture ($pras$[12])
- Price per kg fresh matter in summer feed ration for extensively fattened castrates (prs[17])
- Price per kg fresh matter in summer feed ration for extensively fattened heifers (prs[12])
- Price per kg fresh matter in winter feed ration for extensively fattened castrates (prw[17])
- Price per kg fresh matter in winter feed ration for extensively fattened heifers (prw[12])
- Price per kg minerals for extensively fattened castrates (prm[17])

- Price per kg minerals for extensively fattened heifers (prm[12])
- Amount of minerals per day per extensively fattened castrate (min[17])
- Amount of minerals per day per extensively fattened heifer (min[12])
- Amount of water per castrate and day in extensive fattening (wat[17])
- Amount of water per heifer and day in extensive fattening (wat[12])
- Amount of dung per animal and day in extensive fattening in winter housing ($dungfx$)
- Amount of straw per animal and day in extensive fattening in winter housing ($strawfx$)
- Cost for veterinary treatment per animal in extensive fattening ($costvfx$)
- Fixed cost per animal and day in extensive fattening ($fixcfx$)
- Coefficient for price decrease for castrates involuntarily culled (ratio between the price per kg carcass of involuntarily culled castrates and the price per kg carcass of castrates that reached target slaughter weight, kpr[17])
- Coefficient for price decrease for heifers involuntarily culled (ratio between the price per kg carcass of involuntarily culled heifers and the price per kg carcass of heifers that reached target slaughter weight, kpr[12])
- Governmental support per fattened animal ($dotfatx$)
- Price per kg carcass of extensively fattened castrates for the base class[15] ($prcs$)
- Price per kg carcass of heifers for the base class[16] (prh)

4.2.9 Input file INPUT10.TXT

This file is necessary for **intensive** fattening (option 1 for fattening) of heifers and castrates in Production Systems 1 to 3. If no castrates are fattened the input parameters referring to castrates will be ignored. Losses of animals are defined as animals died[17] during the fattening period as proportion of all animals entering fattening.

If all surplus weaned calves are sold, the parameters connected exclusively with fattening are ignored in the calculations. But some of the parameters (as dressing proportion, price for slaughter animals, number of classes for fleshiness and fat covering) will be needed in each calculation, as there will be always culled heifers and bulls in the cow herd.

The following parameters are read from this file:

- Daily gain of castrates in intensive fattening ($adgwsc$)
- Daily gain of heifers in intensive fattening ($adgwsf$)
- Live weight of castrates at slaughter ($wcfat$)

[15] The "base" class will mostly but not necessarily be the best class. The prices for all other classes are then calculated by multiplying the price of the base class with a coefficient. These coefficients will be given in the input file INPUT18.TXT on page 84. The price coefficient for the "base" class or "reference" class is naturally 1.

[16] see footnote 15

[17] see footnote 12 on page 74

- Live weight of heifers at slaughter ($whfat$)
- Fattened castrates slaughtered before the target slaughter weight expressed as proportion of all intensively fattened castrates ($nccf$)
- Fattened heifers slaughtered before the target slaughter weight expressed as proportion of all intensively fattened heifers ($nfcf$)
- Dressing proportion of castrates not reaching the target slaughter weight as proportion of the dressing proportion of castrates reaching the target slaughter weight ($kdresc$)
- Dressing proportion of heifers not reaching the target slaughter weight as proportion of the dressing proportion of heifers reaching the target slaughter weight ($kdresh$)
- Losses of castrates in intensive fattening ($dccf$)
- Losses of heifers in intensive fattening ($dfcf$)
- Amount of water per day and castrate in intensive fattening (wat[17])
- Amount of water per day and heifer in intensive fattening (wat[12])
- Dry matter per kg feed ration for intensively fattened castrates ($dryf$[17])
- Dry matter per kg feed ration for intensively fattened heifers ($dryf$[12])
- Net energy content per kg dry matter of feed ration for intensively fattened castrates (edf[17])
- Net energy content per kg dry matter of feed ration for intensively fattened heifers (edf[12])
- Protein content per kg dry matter of feed ration for intensively fattened castrates ($pdidf$[17])
- Protein content per kg dry matter of feed ration for intensively fattened heifers ($pdidf$[12])
- Price per kg fresh matter of feed ration for intensively fattened castrates (prf[17])
- Price per kg fresh matter of feed ration for intensively fattened heifers (prf[12])
- Price per kg carcass of intensively fattened castrates for the base class[18] ($prcs$)
- Price per kg carcass of heifers for the base class[19] (prh)
- Coefficient for price decrease for castrates involuntarily culled (ratio between the price per kg carcass of involuntarily culled castrates and the price per kg carcass of castrates that reached target slaughter weight, kpr[17])
- Coefficient for price decrease for heifers involuntarily culled (ratio between the price per kg carcass of involuntarily culled heifers and the price per kg carcass of heifers that reached target slaughter weight, kpr[12])
- Governmental support per fattened animal ($dotfati$)

[18] The "base" class will mostly but not necessarily be the best class. The prices for all other classes are then calculated by multiplying the price of the base class with a coefficient. These coefficients will be given in the input file INPUT17.TXT on page 84. The price coefficient for the "base" class or "reference" class is naturally 1.

[19] see footnote 18

4.2.10 Input file INPUT13.TXT

This file is necessary for Production Systems 1 and 2 only. It includes input parameters referring to breeding heifers from weaning to calving or to selling. Selling of pregnant or not mated heifers is possible. If not enough female calves are reared for replacement the input parameters referring to purchased breeding heifers are to be filled in. The purchased replacements are assumed to be pregnant heifers.

The following parameters are read from this file:

- Daily gain of breeding heifers in the 1st summer season after weaning (after reaching the age of 1 year) ($adgh1s$)
- Daily gain of breeding heifers in the 2nd winter season after weaning (after reaching the age of 1 year) ($adgh2w$)
- Daily gain of breeding heifers in the 2nd summer season after weaning (after reaching the age of 2 years) ($adgh2s$)
- Daily gain of breeding heifers in the 3rd winter season after weaning (after reaching the age of 2 years) ($adgh3w$)
- Daily gain of breeding heifers in the 3rd summer season after weaning (after reaching the age of 3 years) ($adgh3s$)
- Daily gain of breeding heifers in the 4th winter season after weaning (after reaching the age of 3 years) ($adgh4w$)
- Minimal live weight of heifers at first mating ($whmin$)
- Phenotypic standard deviation of the weight of heifers at the first mating period after weaning (at an age of about 1 year) ($sigmawh$)
- Losses in the rearing period of heifers (heifers died from weaning to conception) ($dfrp$)
- Heifers negatively selected on health and exterior before mating and slaughtered as proportion of reared heifers ($sfrp$)
- Pregnant heifers sold expressed as proportion of surplus female calves[20] (phs)
- Breeding heifers sold before mating expressed as proportion of surplus female calves[21] ($nphs$)
- Number of days from the average date of mating heifers to the date of culling barren heifers ($dayshc$)
- Days of pregnancy of purchased (or sold) females for replacement ($dprfrep$)
- Heifers inseminated in 1st oestrus within the mating period as proportion of heifers available for breeding[22] (aih)
- Dry matter per kg summer feed ration for breeding heifers ($drys$[22])

[20] In systems 1 and 2, the sum of the following input parameters must be one: Female calves sold expressed as proportion of surplus female calves (INPUT03.TXT), female calves for fattening expressed as proportion of surplus female calves (INPUT03.TXT), pregnant heifers sold expressed as proportion of surplus female calves and breeding heifers sold before mating expressed as proportion of surplus female calves. In system 3, the first two parameters must sum to one and the last two parameters are not defined.

[21] See footnote 20.

[22] This parameter is not read if only natural mating is used.

- Dry matter per kg winter feed ration for breeding heifers ($dryw$[22])
- Average residual daily dry matter intake of summer feed ration for breeding heifers ($rfis$[22])
- Average residual daily dry matter intake of winter feed ration for breeding heifers ($rfiw$[22])
- Net energy content per kg dry matter of summer feed ration for breeding heifers (eds[22])
- Net energy content per kg dry matter of winter feed ration for breeding heifers (edw[22])
- Protein content per kg dry matter of summer feed ration for breeding heifers ($pdids$[22])
- Protein content per kg dry matter of winter feed ration for breeding heifers ($pdidw$[22])
- Price per kg fresh matter of winter feed ration for breeding heifers (prw[22])
- Price per kg fresh matter of summer feed ration for breeding heifers (prs[22])
- Amount of straw per breeding heifer in winter housing per day ($straw$[22])
- Amount of dung per breeding heifer in winter housing per day ($dung$[22])
- Amount of minerals per day and breeding heifer (min[22])
- Amount of water per day and breeding heifer (wat[22])
- Costs for veterinary treatment per breeding heifer from weaning to calving ($costv$[22])
- Fixed costs from weaning to calving per breeding heifer and day ($fixcrh$)
- Price per kg live weight of breeding heifers at purchase ($prrep$)
- Price per kg live weight of non-pregnant breeding heifers at selling ($prnphse$)
- Price per kg live weight of pregnant heifers at selling ($prphse$)
- Average age of non-pregnant breeding heifers sold before the first mating period after their weaning ($anphse1$)
- Average age of non-pregnant breeding heifers sold between the first and second mating period after their weaning ($anphse2$)
- Non-pregnant breeding heifers sold before the first mating period after their weaning as proportion of all sold non-pregnant breeding heifers ($nphsold1$)
- Non-pregnant breeding heifers sold between the first and second mating period after their weaning as proportion of all sold non-pregnant breeding heifers[23] ($nphsold2$)

[23] The sum of the last two input parameters of INPUT13.TXT must be 1.

4.2.11 Input file INPUT14.TXT

This file is necessary for Production System 3 only. It includes input parameters referring to the costs from purchase to calving for replacement females that are purchased at certain age, weight and days of pregnancy (days of pregnancy may be zero).

The following parameters are read from this file:

- Age of female for replacement at purchase ($agefrep$)
- Weight of female for replacement at purchase ($wfrep$)
- Days of pregnancy of purchased females for replacement ($dprfrep$)
- Number of days from the average date of mating heifers to the date of culling barren heifers ($dayshc$)
- Age of cows at first calving ($agecal$)
- Weight of cows after 1st calving ($wcacal$[0])
- Weight of cows after 2nd calving ($wcacal$[1])
- Amount of dung in winter housing per replacement heifer and day ($dung$[22])
- Amount of minerals per replacement heifer and day (min[22])
- Amount of straw in winter housing per replacement heifer and day ($straw$[22])
- Amount of water per replacement heifer and day (wat[22])
- Dry matter per kg summer feed ration for replacement heifers ($drys$[22])
- Dry matter per kg winter feed ration for replacement heifers ($dryw$[22])
- Average residual daily dry matter intake of summer feed ration for replacement heifers ($rfis$[22])
- Average residual daily dry matter intake of winter feed ration for replacement heifers ($rfiw$[22])
- Net energy content per kg dry matter of summer feed ration for replacement heifers (eds[22])
- Net energy content per kg dry matter of winter feed ration for replacement heifers (edw[22])
- Protein content per kg dry matter of summer feed ration for replacement heifers ($pdids$[22])
- Protein content per kg dry matter of winter feed ration for replacement heifers ($pdidw$[22])
- Price per kg fresh matter of winter feed ration for replacement heifers (prw[22])
- Price per kg fresh matter of summer feed ration for replacement heifers (prs[22])
- Price per kg live weight of replacement heifers at purchase ($prrep$)
- Fixed cost from weaning to calving per replacement heifer and day ($fixcrh$)
- Cost for veterinary treatment per replacement heifer from purchase to calving ($costv$[22])

- Heifers inseminated in 1st oestrus within the mating period as proportion of heifers available for breeding (aih). This input is only read if days of pregnancy of purchased heifers is zero and artificial insemination is used.

4.2.12 Input file INPUT16.TXT

This file contains input parameters for program EWBC (Production Systems 1 to 3) and both options 1 and 2 for fattening (see Section 4.1.1.3). For changing input data, change the number(s) in the matrices. Be careful when changing input parameters. Please notice that the description of the given matrix is posted under the matrix. The rows represent the commercial classes for fleshiness, the columns represent the classes for fat covering. The numbers of rows and columns of all matrices must be in accordance with the appropriate parameters in INPUT08.TXT. The matrices of coefficients of carcass prices show the ratio of the price per kg carcass in the given class to the price in the base class. The price of the base class is an input parameter in the input files INPUT03.TXT and INPUT08.TXT (see Sections 4.2.3 and 4.2.7, respectively). Data for bulls are not read in Production Systems 2 and 3 if there is no fattening of bulls. In Production System 1, they are read always (there are always data from bulls after performance test, even if there is no fattening of bulls).

The following matrices are read from this file:

- Matrix **Pb** - proportions (relative frequencies in %) of bull carcasses in commercial classes for fleshiness and fat covering ($Pb[j][i]$). The sum of all elements of the matrix is 100%.
- Matrix **Pc** - proportions (relative frequencies in %) of cow carcasses in commercial classes for fleshiness and fat covering ($Pc[j][i]$). The sum of all elements of the matrix is 100%.
- Matrix **Prb** - coefficients of carcass prices in commercial classes for fleshiness and fat covering for bulls relative to the base class (insert value 1 for the base class) ($Prb[j][i]$)
- Matrix **Prc** - coefficients of carcass prices in commercial classes for fleshiness and fat covering for cows relative to the base class (insert value 1 for the base class) ($Prc[j][i]$)

Example: A short example will be given. Assume that there are three classes for fleshiness (1,2,3) and two classes for fat covering (1,2). Let us write the prices for bulls (in MU per kg carcass) in the individual classes as matrix where the three rows refer to the three classes for fleshiness and the three columns to the classes for fat covering:

$$\begin{bmatrix} 50 & 48 \\ 45 & 42 \\ 40 & 38 \end{bmatrix} .$$

Assume the combination of the first class for fleshiness and the first class for fat covering is considered as base class (with the value 50). Then the elements of matrix **Prb** are simply obtained by dividing all elements of the matrix of prices by this value 50:

$$\mathbf{Prb} = \begin{bmatrix} 1.00 & 0.96 \\ 0.90 & 0.84 \\ 0.80 & 0.76 \end{bmatrix} .$$

4.2.13 Input file INPUT17.TXT

This file contains input parameters for Production Systems 1 to 3, for option 1 of fattening (intensive fattening). The data for heifers are also read for option 0 of fattening (no fattening). For changing input data, change the number(s) in the matrices. Be careful when changing input parameters. Please notice that the description of the given matrix is posted under the matrix. The rows represent the commercial classes for fleshiness, the columns represent the classes for fat covering. The numbers of rows and columns of all matrices must be in accordance with the appropriate parameters in INPUT08.TXT. The matrix of coefficients of carcass prices shows the ratio of the price per kg carcass in the given class to the price in the base class. The price of the base class is an input parameter in the input file INPUT10.TXT (see Section 4.2.9). The data for castrates are not read if there are no castrates in the System.

The following matrices are read from this file:

- Matrix **Ph** - proportions (relative frequencies in %) of heifer carcasses in commercial classes for fleshiness and fat covering. The sum of all elements of the matrix is 100%. ($Ph[j][i]$)
- Matrix **Pcs** - proportions (relative frequencies in %) of castrate carcasses in commercial classes for fleshiness and fat covering. The sum of all elements of the matrix is 100%. ($Pcs[j][i]$)
- Matrix **Prh** - coefficients of carcass prices in commercial classes for fleshiness and fat covering for heifers relative to the base class ($Prh[j][i]$))
- Matrix **Prcs** - coefficients of carcass prices in commercial classes for fleshiness and fat covering for castrates relative to the base class ($Prcs[j][i]$))

See also the example in the section for input file INPUT16.TXT on the preceding page.

4.2.14 Input file INPUT18.TXT

This file contains input parameters for Production Systems 1 to 3, only for option 2 of fattening (see Section 4.1.1.3). The parameters are the same as in INPUT17.TXT (see Section 4.2.13). The numbers of rows and columns of all matrices must be in accordance with the appropriate parameters in INPUT08.TXT. The price of the base class is an input parameter in the input file INPUT09.TXT (see Section 4.2.8). See also the example in the section for input file INPUT16.TXT on the previous page. The data for castrates are not read if there are no castrates in the System.

4.2.15 Input file INPUT19.TXT

This file contains two parameters of the lactation curve. They are needed for Production Systems 1 to 3. The file is only read if the parameters are calculated according to Fox et al. [5]. For details see Section 2.3.1.

The two parameters are:

- Peak milk yield in kg per day (at pasture with suckling calf) ($mpm0$)
- Expected milk production level of the herd (1 - lowest, 9 - highest) (pl)

4.2.16 Input file INPUT20.TXT

This file contains parameters for the lactation curve. The file is needed for Production Systems 1 to 3. The file is only read if the parameters are not calculated according to Fox et al. [5]. The parameters are parameters of the Wood function ([32], see equation (2.4) in Section 2.3).

The following parameters are read from this file:

- Parameter a for two year old cows ($a2$)
- Parameter a for three year old cows ($a3$)
- Parameter a for four year old cows ($a4$)
- Parameter a for mature cows (am)
- Parameter b for two year old cows ($b2$)
- Parameter b for three year old cows ($b3$)
- Parameter b for four year old cows ($b4$)
- Parameter b for mature cows (bm)
- Parameter c for two year old cows ($c2$)
- Parameter c for three year old cows ($c3$)
- Parameter c for four year old cows ($c4$)
- Parameter c for mature cows (cm)

4.2.17 Input file INPUT26.TXT

This file is needed for Production Systems 1 to 3 and for both options 1 and 2 of fattening. It contains input parameters for gene flow(see Section 2.8).

For changing input data, change the number(s). Be careful when changing input parameters. Please notice that the description of the given parameter or vector is posted under the number(s). The following parameters are read:

- Number of age classes for sires (acs)
- Number of age classes for dams (number of reproductive cycles + age at calving in years[24] - 1) (acd)
- Number of the sex-age class for which the gene flow will be calculated (see Section 2.8 for further explanation) (n_sac)
- Length of the investment period (l_inv)
- Proportion of genes from individual age classes of sires in the male progeny (path sires to sires, the numbers must sum to 0.5) ($PM[i][j]$, $i = 1$, $j = 1, \ldots, acs$)
- Proportion of genes from individual age classes of sires in the female progeny (path sires to dams) or in slaughter progeny (the numbers must sum to 0.5) ($PM[i][j]$, $i = acs + 1$, $j = 1, \ldots, acs$)
- Proportion of genes from individual age classes of dams in the male progeny (path dames to sires, the numbers must sum to 0.5) ($PM[i][j]$, $i = 1$, $j = acs + 1, \ldots, acs + acd$)

[24] Age must be rounded up to the next integer.

4.2.18 Input file INPUT34.TXT

This file is important for the calculation of relative economic weights. In this file, you are asked to choose between two alternative definitions of the same trait. The two definitions are presented with the number of the traits (as given in Appendix A.2) in parentheses. Type the number of the definition you prefer.

The following selections are to be made:

- Select (6) average daily gain of calves from birth to 1st weighing or (26) weight gain of calves from birth to 1st weighing ($flag$[1])
- Select (7) average daily gain of calves from 1st to 2nd weighing or (27) weight gain of calves from 1st to 2nd weighing ($flag$[2])
- Select (8) average daily gain of calves from 2nd to 3rd weighing or (28) weight gain of calves from 2nd to 3rd weighing ($flag$[3])
- Select (11) cow losses in per cent or (29) average lifetime of cows in years ($flag$[4])

4.2.19 Input file INPUT35.TXT

This file is necessary if genetic standard deviations are known for the direct and maternal components of the traits. It contains input parameters (genetic standard deviations) for calculating the relative economic weights of traits. If there are direct and maternal components of a trait two input values are to be given, otherwise only one value is given. Keep attention that the genetic standard deviations must be given in correct units. The genetic standard deviations must be for the breed the economic weights are calculated for. The appropriate input is skipped if the trait is not considered in the calculation. The individual inputs are:

- Genetic standard deviation for direct and maternal component of calving performance score ($gstd\_d$[1], $gstd\_m$[1])
- Genetic standard deviation for direct and maternal components of losses of calves at calving ($gstd\_d$[2], $gstd\_m$[2])
- Genetic standard deviation for direct and maternal components of losses of calves from 48 hour after calving till weaning ($gstd\_d$[3], $gstd\_m$[3])
- Genetic standard deviation for mature weight of cows ($gstd\_m$[4])
- Genetic standard deviation for direct and maternal components of birth weight ($gstd\_d$[5], $gstd\_m$[5])
- Genetic standard deviation for direct and maternal components of average daily gain of calves from birth to 1st weighing ($gstd\_d$[6], $gstd\_m$[6])
- Genetic standard deviation for direct and maternal components of average daily gain of calves from 1st to 2nd weighing ($gstd\_d$[7], $gstd\_m$[7])
- Genetic standard deviation for direct and maternal components of average daily gain of calves from 2nd to 3rd weighing ($gstd\_d$[8], $gstd\_m$[8])
- Genetic standard deviation for daily gain in fattening ($gstd\_d$[9])
- Genetic standard deviation for dressing percentage ($gstd\_d$[10])
- Genetic standard deviation for cow losses ($gstd\_m$[11])

- Genetic standard deviation for conception rate of heifers ($gstd\_d[12]$)
- Genetic standard deviation for conception rate of cows ($gstd\_m[13]$)
- Genetic standard deviation for mean class of fleshiness ($gstd\_d[18]$)
- Genetic standard deviation for mean class of fat covering ($gstd\_d[23]$)
- Genetic standard deviation for direct and maternal components of weight gain of calves from birth to 1st weighing ($gstd\_d[26]$, $gstd\_m[26]$)
- Genetic standard deviation for direct and maternal components of weight gain of calves from 1st to 2nd weighing ($gstd\_d[27]$, $gstd\_m[27]$)
- Genetic standard deviation for direct and maternal components of weight gain of calves from 2nd to 3rd weighing ($gstd\_d[28]$, $gstd\_m[28]$)
- Genetic standard deviation for lifetime of cows ($gstd\_d[29]$, $gstd\_m[29]$)
- Genetic standard deviation for dry matter intake of heifers ($gstd\_d[30]$)
- Genetic standard deviation for dry matter intake in intensive fattening ($gstd\_d[31]$)
- Genetic standard deviation for dry matter intake in extensive fattening ($gstd\_d[32]$)
- Genetic standard deviation for dry matter intake of adult animals" ($gstd\_m[33]$)

That means, the genetic standard deviations for the direct and maternal components of the traits are read to the vectors $gstd\_d[i]$ and $gstd\_m[i]$, respectively, where i is the number of trait according to Appendix A.2.

4.2.20 Input file INPUT36.TXT

This file is necessary if genetic standard deviations of the traits are known and are not differentiated between direct and maternal components. It contains input parameters (genetic standard deviations) for calculating the standardised marginal economic values of traits. Keep attention that the genetic standard deviations are given in the correct units. The genetic standard deviations must be for the breed the economic values are calculated for. The appropriate input is skipped if the trait is not considered in the calculation.

The genetic standard deviations are read for the same traits as in INPUT35.TXT. They are read to the vector $gstd\_d[i]$ where i is the number of the trait according to Appendix A.2.

4.3 Data input files for program EWDC (Production System 4)

A survey of data input files for Production System 4 needed for running the program EWDC is given in Table 4.2. At the beginning of each input file a comment is placed starting with /* and ending with */. The program recognises the slash (/) as the beginning and the end of the comment. When changing this text, do not use slashes within the comment (stars can be used within the comment).

For each input, the names of variables as they are used in the program are given in parentheses.

Table 4.2: Survey of data input files for program EWDC (Production System 4)

Input file	Remark
INPUT07.TXT	
INPUT11.TXT	
INPUT12.TXT	
INPUT15.TXT	
INPUT21.TXT	
INPUT22.TXT	
INPUT23.TXT	
INPUT24.TXT	
INPUT25.TXT	
INPUT27.TXT	
INPUT28.TXT	
INPUT29.TXT	only if data for mastitis are available
INPUT30.TXT	only if data for mastitis are available
INPUT31.TXT	only if relative economic weights are calculated
INPUT32.TXT	only if relative economic weights are calculated
INPUT33.TXT	only if relative marginal economic values are calculated
INPUT37.TXT	only if data for claw disease are available
INPUT38.TXT	only if data for claw disease are available
FROM1_3.TXT[a]	needed only in case that there is a transfer of data between programs EWBC and EWDC
T.TXT[a]	needed only in case that there is a transfer of data between programs EWBC and EWDC

[a]These files are produced by the EWBC program, don't edit them.

4.3.1 Input file INPUT07.TXT

This file includes input parameters describing reproductive cycles (lactations) of dairy cows. In each reproductive cycle, cows can be mated to dairy bulls or to beef bulls. Losses of cows (mortality rate), culling, conception rate and abortion are assumed to be the same in both groups of cows, but differences are possible for dystocia occurrence. Therefore altogether four groups of cows are differentiated according to calving performance: cows with easy calving and cows with dystocia in both mating types. The input parameters for losses of cows and calves, for conception rate etc. can differ between the groups with and without dystocia occurrence.

All input data are arranged in the following way: each parameter takes three parts (mostly one part is one row). The vector of its values for reproductive cycles 1 to LL or 1 to $LL-1$ stands in the first part, the string expression in the second part describes the parameter and the last string in the third part contains the units of the parameter. This field may be an empty string.

Two groups of calf losses at calving are differentiated here: stillborn calves (12th and 13rd vectors) and calves died till 48 hours after birth (14th and 15th vectors). If only one summary statistics exists for calf losses at birth which includes all calves died till a certain time after birth, insert this data in the vectors for stillborn calves and fill only zeros in the vectors for calves died to 48 hours after birth.

Some of the probabilities of calving score at the end of the input file may be of no concern. For example, if the number of classes for calving performance (specified in INPUT11.TXT) is 4, all values for calving scores 5 and 6 are ignored. If there is no crossbreeding in the system, the calving scores for cross-bred animals are not read. Do not omit rows with unnecessary information in the input file. The program will skip the inputs which are not needed.

The following parameters are given in the file:

- Vector of cow losses within reproductive cycles 1 to LL as proportion of cows entered the reproductive cycle (cow mortality rates, $pp[19 + i \times 6]$, $i = 1, \ldots, LL$)
- Vector of cows culled within reproductive cycles 1 to LL for health problems other than dystocia as proportion of cows entered the reproductive cycle ($culh[i]$, $i = 1, \ldots, LL$). Cows culled for failure to conceive must not be included.
- Vector of cows culled within reproductive cycles 1 to LL for low milk production as proportion of cows entered the reproductive cycle ($culvol[i]$, $i = 1, \ldots, LL$)
- Vector of probabilities of abortion for cows conceived in reproductive cycles 1 to LL ($ab[i]$, $i = 1, \ldots, LL$)
- Vector of still-born calves after dystocia as proportion of cows having dystocia in reproductive cycles 1 to LL ($stcd[i]$, $i = 1, \ldots, LL$)
- Vector of still-born calves after easy calving as proportion of cows having easy calving in reproductive cycles 1 to LL ($stce[i]$, $i = 1, \ldots, LL$)
- Vector of calves died to 48 hours as proportion of calves born alive after dystocia in reproductive cycles 1 to LL ($dcd[i]$, $i = 1, \ldots, LL$)
- Vector of calves died to 48 hours as proportion of calves born alive after easy calving in reproductive cycles 1 to LL ($dce[i]$, $i = 1, \ldots, LL$)
- Vector of females mated with beef bulls as proportion of females mated in reproductive cycles 1 to $LL - 1$ ($pcross[i]$, $i = 1, \ldots, LL - 1$)
- Vector of conception rate after ith insemination for cows not having dystocia ($ecrinc[i]$, $i = 1$ to $inmax$ where $inmax$ is the maximal number of inseminations for cows - see INPUT11.TXT on the following page)
- Vector of conception rate after ith insemination for heifers ($crinh[i]$, $i = 1$ to $inmaxh$ where $inmaxh$ is the maximal number of inseminations for heifers - see INPUT11.TXT on the next page)
- Probability of calving score 2 when a pure-bred dairy female calf is born in reproductive cycles 1 to LL[25] ($dysff[1][0][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 2 when a pure-bred dairy male calf is born in reproductive cycles 1 to LL ($dysmm[1][0][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 3 when a pure-bred dairy female calf is born in reproductive cycles 1 to LL ($dysff[2][0][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 3 when a pure-bred dairy male calf is born in reproductive cycles 1 to LL ($dysmm[2][0][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 4 when a pure-bred dairy female calf is born in reproductive cycles 1 to LL ($dysff[3][0][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 4 when a pure-bred dairy male calf is born in reproductive cycles 1 to LL ($dysmm[3][0][i]$, $i = 1, \ldots, LL$)

[25] See Section 2.6.4.1 for the definition of calving scores

- Probability of calving score 5 when a pure-bred dairy female calf is born in reproductive cycles 1 to LL ($dysff[4][0][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 5 when a pure-bred dairy male calf is born in reproductive cycles 1 to LL ($dysmm[4][0][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 6 when a pure-bred dairy female calf is born in reproductive cycles 1 to LL ($dysff[5][0][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 6 when a pure-bred dairy male calf is born in reproductive cycles 1 to LL ($dysmm[5][0][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 2 when a cross-bred (beef x dairy) female calf is born in reproductive cycles 1 to LL ($dysff[1][1][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 2 when a cross-bred (beef x dairy) male calf is born in reproductive cycles 1 to LL ($dysmm[1][1][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 3 when a cross-bred (beef x dairy) female calf is born in reproductive cycles 1 to LL ($dysff[2][1][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 3 when a cross-bred (beef x dairy) male calf is born in reproductive cycles 1 to LL ($dysmm[2][1][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 4 when a cross-bred (beef x dairy) female calf is born in reproductive cycles 1 to LL ($dysff[3][1][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 4 when a cross-bred (beef x dairy) male calf is born in reproductive cycles 1 to LL ($dysmm[3][1][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 5 when a cross-bred (beef x dairy) female calf is born in reproductive cycles 1 to LL ($dysff[4][1][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 5 when a cross-bred (beef x dairy) male calf is born in reproductive cycles 1 to LL ($dysmm[4][1][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 6 when a cross-bred (beef x dairy) female calf is born in reproductive cycles 1 to LL ($dysff[5][1][i]$, $i = 1, \ldots, LL$)
- Probability of calving score 6 when a cross-bred (beef x dairy) male calf is born in reproductive cycles 1 to LL ($dysmm[5][1][i]$, $i = 1, \ldots, LL$)

4.3.2 Input file INPUT11.TXT

This file includes input parameters describing the dairy cow herd which are arranged in the following way: parameters for reproduction, growth, mortality, feeding, prices and costs. Data referring to beef cattle are ignored if there is no crossing.

- Number of classes for calving score (DD)
- For defining dystocia give the lowest score of calving performance which is considered to be dystocia. For example, if there are scores 1 to 5 and scores 3 to 5 will be considered as dystocia your input will be 3. ($dyscl$)
- Gestation length ($lgpre$)
- Average interval between calving and first insemination ($intcm$)
- Average interval between two subsequent inseminations[26] ($inint$)

[26] Insert here the real average interval from the population data and not a theoretical value (i.e. interval between two oestruses).

- Number of days dry (dd)
- Maximal number of inseminations per cow after calving ($inmax$)
- Maximal number of inseminations per heifer ($inmaxh$)
- Number of re-inseminations per oestrus (nr)
- Decrease in conception rate of cows after dystocia averaged over reproductive cycles 1 to LL ($crdys$)
- Culling rate of cows after dystocia (cmd)
- Fat content in milk (fat)
- Protein content in milk ($prot$)
- Mature weight of dairy cows (weight of cows after 3rd calving) ($mcwd$)
- Mature weight of beef cows of the same breed the bulls of which are used for terminal crossing (weight of cows after 3rd calving) ($mcwb$)
- Weight gain for pregnancy (= loss of cow weight after calving) averaged over reproductive cycles 1 to LL ($wpreg$)
- Average daily gain of cows in the 1st reproductive cycle ($adg1cow$)
- Average number of days between calving and culling cows due to dystocia ($ndaydys$)
- Dressing proportion of cows ($drescw$)
- Losses of feed through wasting in cow herds or in rearing of young animals ($loswf$)
- Losses of feed through wasting in fattening ($losff$)
- Dry matter per kg feed for cows (average feed ration through the whole calving interval) ($dryf$[30])
- Net energy per kg dry matter of feed ration for cows (edf[30])
- Protein per kg dry matter of feed ration for cows ($pdid$[30])
- Average residual daily dry matter intake of cows (difference between the daily actual and predicted dry matter intake, rfi[30])
- Adjustment factor for breed energy requirement for maintenance - dry cows[27] (kbd)
- Adjustment factor for breed energy requirement for maintenance - lactating cows (kbl)
- Adjustment factor for energy requirement for maintenance according to technology - pasture (ktp)
- Adjustment factor for energy requirement for maintenance according to technology - bind technology (ktb)

[27] In example data, the values for this and the following four adjustment factors were taken from [5].

- Adjustment factor for energy requirement for maintenance according to technology - free technology (ktf)
- Amount of water per cow and day (wat[30])
- Amount of straw per cow and day ($straw$[30])
- Amount of dung per cow and day ($dung$[30])
- Price per kg fresh matter of feed ration for cows (prf[30])
- Price per kg dung ($prdg$)
- Price per kg straw ($prst$)
- Price per litre water ($prwt$)
- Price of one portion of semen from AI dairy bulls including external labour for insemination ($praid$)
- Cost per re-insemination from dairy bulls including external labour for insemination ($prairdd$)
- Price of one portion of semen from AI beef bulls including external labour for insemination ($praib$)
- Cost per re-insemination from beef bulls including external labour for insemination ($prairb$)
- Price per kg carcass of cows in the base class[28] for carcass grading (prc)
- Ratio of price per kg carcass of cows involuntarily culled to the price per kg carcass of cows voluntarily culled (kpr[30])
- Cost for removing and rendering of a dead cow ($costd$[25])
- Cost for veterinary treatment per cow and reproductive cycle ($costv$[30])
- Veterinary cost connected with calving score 1 ($vetdys$[0])
- Veterinary cost connected with calving score 2 ($vetdys$[1])
- Veterinary cost connected with calving score 3 ($vetdys$[2])
- Veterinary cost connected with calving score 4 ($vetdys$[3])
- Veterinary cost connected with calving score 5 ($vetdys$[4])
- Veterinary cost connected with calving score 6 ($vetdys$[5])
- Stock-man hours connected with calving score 1 ($labdys$[0])
- Stock-man hours connected with calving score 2 ($labdys$[1])
- Stock-man hours connected with calving score 3 ($labdys$[2])
- Stock-man hours connected with calving score 4 ($labdys$[3])
- Stock-man hours connected with calving score 5 ($labdys$[4])

[28] The "base" class will mostly but not necessarily be the best class. The prices for all other classes are then calculated by multiplying the price of the base class with a coefficient. These coefficients will be given in the input file INPUT24.TXT on page 100. The price coefficient for the "base" class or "reference" class is naturally 1.

- Stock-man hours connected with calving score 6 ($labdys[5]$)
- Cost per stock-man hour (needed for dystocia cost) ($costlab$)
- Variable costs for milk when increasing the milk yield above average (e.g. energy for cooling, transport costs; feeding costs are not part of the variable costs.) ($varmilk$)
- Fixed cost per cow and day ($fix[30]$)
- Discount rate (u)
- Governmental financial support per kg milk ($dotmilk$)
- Governmental financial support per cow and year (e.g. for culled cows) ($dotcowo$)
- Governmental financial support per cow in performance test and year ($dotcowh$)
- Governmental financial support per exported male calf ($dotexpm$)
- Governmental financial support per fattened animal ($dotfati$)
- Proportion of cows performance tested ($herdbook$)
- Dairy heifers mated with beef bulls as proportion of all mated dairy heifers (this parameter is read only if there is crossbreeding in the system) ($pcrossh$)

4.3.3 Input file INPUT12.TXT

This file is necessary for program EWDC only if reared breeding male calves are kept to higher age at farms, that means stay at farms after the rearing period of calves till their selling to AI stations. The following parameters are read:

- Daily gain of bulls from the end of the rearing period of calves till selling ($adg10$)
- Price per kg fresh matter of feed ration for breeding bulls from the end of the rearing period of calves till selling ($prf10$)
- Protein content per kg dry matter of feed ration for breeding bulls from the end of the rearing period of calves till selling ($pdid10$)
- Net energy content per kg dry matter of feed ration for breeding bulls from the end of the rearing period of calves till selling ($edf10$)
- Dry matter per kg feed ration for breeding bulls from the end of the rearing period of calves till selling ($dryf10$)
- Average residual daily dry matter intake of breeding bulls from the end of the rearing period of calves till selling (the difference between the daily actual and predicted dry matter intake, $rfi10$)
- Amount of dung per breeding bull per day ($dung10$)
- Amount of straw per breeding bull per day ($straw10$)
- Amount of water per breeding bull per day ($wat10$)
- Cost for veterinary treatment per bull from the end of the rearing period of calves till selling ($costvet10$)
- Fixed costs per breeding bull per day ($fix10$)
- Governmental support per breeding bull per day ($dottest$)

4.3.4 Input file INPUT15.TXT

This file includes input parameters connected with progeny. Two types of calving (after pure-bred and cross-bred mating) are distinguished giving two types of progeny (pure-bred and cross-bred). The first number refers to pure-bred (dairy) progeny and must be always given. The second number is for cross-bred progeny and can be omitted if there is no crossbreeding in the system. If a second number is given in a system without crossbreeding, this number is ignored and its value is of no importance (that means you can insert any value for it). The inputs for castrates are read only if there are castrates in the system. Similarly, the inputs for bulls in fattening are only read if there is fattening of bulls. The proportion of male calves for fattening is calculated from the first two inputs of this file. Here is a list of the parameters read from this file:

- Proportion of male calves alive at 48 hours after birth that are determined for selling outside of the evaluated production system ($mxmc[0]$, $mxmc[1]$)
- Proportion of pure-bred male calves alive at 48 hours after birth that are sold as breeding males (e.g. to test stations or AI stations) ($mtest[0]$, no input for cross-breds.)
- Castrates for fattening as proportion of male calves available for fattening ($pcmf[0]$, $pcmf[1]$). These numbers should be in agreement with the options for castrates in fattening in file PARAD.TXT. That means e.g. if no pure-bred castrates are assumed for fattening in PARAD.TXT, then $pcmf[0] = 0$ etc. If in PARAD.TXT the condition of no castrates in fattening is given, the appropriate variables are automatically set to zero. If in PARAD.TXT it is assumed that there are castrates in fattening and the appropriate input variable in INPUT15.TXT is zero, an error message occurs.
- Sold cross-bred female calves as proportion of reared cross-bred female calves ($exfc$). This input is read only if the option for Utilisation of cross-bred female dairy x beef calves which are not needed for replacement in PARAD.TXT is set to 4.
- Weight of female calves at birth ($bwf[0]$, $bwf[1]$)
- Weight of male calves at birth ($bwm[0]$, $bwm[1]$)
- Age of calves at the end of the first feeding period ($agec1[0]$, $agec1[1]$)
- Age of calves at the end of the rearing period[29] ($agew[0]$, $agew[1]$)
- Age of female calves sold ($age[8]$, $age[CC + 8]$)
- Age of male calves sold ($age[9]$, $age[CC + 9]$)
- Daily gain of female calves from birth till the end of the rearing period ($adgcf[0]$, $adgcf[1]$)
- Daily gain of male calves from birth till the end of the rearing period ($adgcm[0]$, $adgcm[1]$)
- Age of male breeding calves at selling to the performance test stations or AI stations ($age[10]$, $age[CC + 10]$)
- Weight of heifers at 1st mating ($whmat1[0]$, $whmat1[1]$)

[29] During rearing of calves, two feeding periods are differentiated for which different feed rations may be defined.

- Daily gain of breeding heifers from the end of the rearing period to 1st mating ($adghm[0]$, $adghm[1]$)
- Daily gain of breeding heifers from the 1st mating to calving (without foetus) ($adghmc[0]$, $adghmc[1]$)
- Days from mating heifers to slaughter because of no pregnancy ($dayshc[0]$, $dayshc[1]$)
- Age of not mated breeding heifers at selling ($age[23]$, $age[CC + 23]$)
- Age of pregnant heifers at selling ($age[24]$, $age[CC + 24]$)
- Daily gain of heifers in fattening ($adgwsf[0]$, $adgwsf[1]$)
- Daily gain of bulls in fattening ($adgwsm[0]$, $adgwsm[1]$)
- Daily gain of castrates in fattening ($adgwsc[0]$, $adgwsc[1]$)
- Dressing proportion of heifers ($dresh[0]$, $dresh[1]$)
- Dressing proportion of bulls ($dresb[0]$, $dresb[1]$)
- Dressing proportion of castrates ($dresc[0]$, $dresc[1]$)
- Losses of calves in the rearing period ($dcw[0]$, $dcw[1]$)
- Losses of bulls in fattening ($dmcf[0]$, $dmcf[1]$).
- Fattened bulls slaughtered before reaching target slaughter weight as proportion of all fattened bulls ($nmcf[0]$, $nmcf[1]$).
- Losses of castrates in fattening ($dccf[0]$, $dccf[1]$).
- Fattened castrates slaughtered before reaching target slaughter weight as proportion of all fattened castrates ($nccf[0]$, $nccf[1]$).
- Losses of heifers in fattening ($dfcf[0]$, $dfcf[1]$).
- Fattened heifers slaughtered before reaching target slaughter weight as proportion of all fattened heifers ($nfcf[0]$, $nfcf[1]$).
- Losses of heifers from the end of the rearing period to 1st insemination ($loshin[0]$, $loshin[1]$).
- Heifers negatively selected before mating and slaughtered as proportion of reared heifers ($sfrp[0]$, $sfrp[1]$).

4.3.5 Input file INPUT21.TXT

This file includes input parameters for nutrition and other costs for reared and fattened progeny and for cows. Two groups of progeny are differentiated: pure-bred dairy progeny and cross-bred progeny so that up to two numbers are given for each input. The first number refers to pure-bred (dairy) progeny and must be always given. The second number is for cross-bred progeny and can be omitted if there is no crossbreeding in the system. If the second number is given in a system without crossbreeding, this number is ignored and its value is of no importance (that means you can insert any value for it). Inputs for castrates are ignored if there are no castrates in the system. Similarly, inputs for heifers and bulls in fattening are ignored if there is no fattening of these categories.

The input parameters are:

- Dry matter per kg feed ration for reared calves in the first feeding period[30] ($dryfwf[0]$, $dryfwf[1]$)
- Net energy content per kg dry matter of feed ration for reared calves in the first feeding period ($edfwf[0]$, $edfwf[1]$)
- Protein content per kg dry matter of feed ration for reared calves in the first feeding period ($pdidwf[0]$, $pdidwf[1]$)
- Average residual daily dry matter intake of female calves in the first feeding period (difference between the daily actual and predicted dry matter intake, $rfifc1[0]$, $rfifc1[1]$)
- Average residual daily dry matter intake of male calves in the first feeding period (difference between the daily actual and predicted dry matter intake, $rfimc1[0]$, $rfimc1[1]$)
- Price per kg fresh matter of feed ration for reared calves in the first feeding period ($prfwf[0]$, $prfwf[1]$)
- Dry matter per kg feed ration for reared calves in the second feeding period ($dryfwf2[0]$, $dryfwf2[1]$)
- Net energy content per kg dry matter of feed ration for reared calves in the second feeding period ($edfwf2[0]$, $edfwf2[1]$)
- Protein content per kg dry matter of feed ration for reared calves in the second feeding period ($pdidwf2[0]$, $pdidwf2[1]$)
- Price per kg fresh matter of feed ration for reared calves in the second feeding period ($prfwf2[0]$, $prfwf2[1]$)
- Average residual daily dry matter intake of female calves in the second feeding period (difference between the daily actual and predicted dry matter intake, $rfifc2[0]$, $rfifc2[1]$)
- Average residual daily dry matter intake of male calves in the second feeding period (difference between the daily actual and predicted dry matter intake, $rfimc2[0]$, $rfimc2[0]$)
- Amount of water per reared calf and day ($watwf[0]$, $watwf[1]$)
- Amount of dung per reared calf and day ($dungwf[0]$, $dungwf[1]$)
- Amount of straw per reared calf and day ($strawwf[0]$, $strawwf[1]$)
- Cost for veterinary treatment per reared calf for the whole rearing period ($costvetwf[0]$, $costvetwf[1]$)
- Fixed cost per reared calf and day ($fixwf[0]$, $fixwf[1]$)
- Dry matter per kg feed ration for breeding heifers ($dryf[22]$, $dryf[CC + 22]$)
- Net energy content per kg dry matter of feed ration for breeding heifers ($edf[22]$, $edf[CC + 22]$)
- Protein content per kg dry matter of feed ration for breeding heifers ($pdid[22]$, $pdid[CC + 22]$)

[30] During rearing of calves, two feeding periods are differentiated for which different feed rations may be defined.

- Price per kg fresh matter of feed ration for breeding heifers (prf[22], prf[CC+22])
- Average residual daily dry matter intake of breeding heifers (difference between the daily actual and predicted dry matter intake, rfi[22], rfi[$CC + 22$])
- Amount of water per breeding heifer and day (wat[22], wat[$CC + 22$])
- Amount of dung per breeding heifer and day ($dung$[22], $dung$[$CC + 22$])
- Amount of straw per breeding heifer and day ($straw$[22], $straw$[$CC + 22$])
- Cost for veterinary treatment per breeding heifer from the end of rearing calves to calving ($costvet$[22], $costvet$[$CC + 22$])
- Fixed cost per breeding heifer from the end of rearing period of calves to calving and per day (fix[22], fix[$CC + 22$])
- Dry matter per kg feed ration for fattened bulls ($dryf$[14], $dryf$[$CC + 14$])
- Net energy content per kg dry matter of feed ration for fattened bulls (edf[14], edf[$CC + 14$])
- Protein content per kg dry matter of feed ration for fattened bulls ($pdid$[14], $pdid$[$CC + 14$])
- Price per kg fresh matter of feed ration in fattening of bulls (prf[14], prf[CC+14])
- Average residual daily dry matter intake of fattened bulls (the difference between the daily actual and predicted dry matter intake, rfi[14], rfi[CC+14])
- Amount of water per bull and day in fattening (wat[14], wat[$CC + 14$])
- Amount of dung per bull and day in fattening ($dung$[14], $dung$[$CC + 14$])
- Amount of straw per bull and day in fattening ($straw$[14], $straw$[$CC + 14$])
- Cost for veterinary treatment per bull in the whole fattening period ($costvet$[14], $costvet$[$CC + 14$])
- Fixed cost per bull and day in fattening (fix[14], fix[$CC + 14$])
- Dry matter per kg feed ration for fattened castrates ($dryf$[17], $dryf$[CC+17])
- Net energy content per kg dry matter of feed ration for fattened castrates (edf[17], edf[$CC + 17$])
- Protein content per kg dry matter of feed ration for fattened castrates ($pdid$[17], $pdid$[$CC + 17$])
- Price per kg fresh matter of feed ration in fattening of castrates (prf[17], prf[$CC + 17$])
- Average residual daily dry matter intake of fattened castrates (difference between the daily actual and predicted dry matter intake, rfi[17], rfi[CC+17])
- Amount of water per castrate and day in fattening (wat[17], wat[$CC + 17$])
- Amount of dung per castrate and day in fattening ($dung$[17], $dung$[$CC + 17$])
- Amount of straw per castrate and day in fattening ($straw$[17], $straw$[CC+17])

- Cost for veterinary treatment per castrate in the whole fattening period ($costvet[17]$, $costvet[CC+17]$)
- Fixed cost per castrate and day in fattening ($fix[17]$, $fix[CC+17]$)
- Dry matter per kg feed ration for fattened heifers ($dryf[12]$, $dryf[CC+12]$)
- Net energy content per kg dry matter of feed ration for fattened heifers ($edf[12]$, $edf[CC+12]$)
- Protein content per kg dry matter of feed ration for fattened heifers ($pdid[12]$, $pdid[CC+12]$)
- Price per kg fresh matter of feed ration in fattening of heifers ($prf[12]$, $prf[CC+12]$)
- Average residual daily dry matter intake of fattened heifers (the difference between the daily actual and predicted dry matter intake, $rfi[12]$, $rfi[CC+12]$)
- Amount of water per fattened heifer and day ($wat[12]$, $wat[CC+12]$)
- Amount of dung per heifer and day in fattening ($dung[12]$, $dung[CC+12]$)
- Amount of straw per heifer and day in fattening ($straw[12]$, $straw[CC+12]$)
- Cost for veterinary treatment per heifer in the whole fattening period ($costvet[12]$, $costvet[CC+12]$)
- Fixed cost per heifer and day in fattening ($fix[12]$, $fix[CC+12]$)
- Costs for removing and rendering of a dead young animal (breeding heifer or animal in fattening) ($costdf[0]$, $costdf[1]$)
- Costs for removing and rendering of a dead calf ($costdcf[0]$, $costdcf[1]$)
- Price of a female reared calf for sale (per kg live weight or per animal) ($pr[8]$, $pr[CC+8]$ or $pranim[8]$, $pranim[CC+8]$, respectively)
- Price of a male reared calf for sale (per kg live weight or per animal) ($pr[9]$, $pr[CC+9]$ or $pranim[9]$, $pranim[CC+9]$, respectively)
- Price of a male sold to the test station or to A.I. station (per kg live weight or per animal) ($pr[10]$, $pr[CC+10]$ or $pranim[10]$, $pranim[CC+10]$, respectively)
- Price of a not mated breeding heifer for sale (per kg live weight or per animal) ($pr[23]$, $pr[CC+23]$ or $pranim[23]$, $pranim[CC+23]$, respectively)
- Price of a pregnant heifer at selling (per kg live weight or per animal) ($pr[24]$, $pr[CC+24]$ or $pranim[24]$, $pranim[CC+24]$, respectively)

4.3.6 Input file INPUT22.TXT

This file contains the parameters b, c and d for the lactation curve of Wood [32] adopted by Fox (Equation 2.5, [5]) for dairy cows. Parameter a of the modified Wood curve is calculated by Equations (2.12) and (2.13).

- Average milk yield per cow and year ($milk$)
- Parameter b for the first lactation ($b1$)

- Parameter b for the second lactation ($b2$)
- Parameter b for third and higher lactations ($b3$)
- Parameter c for the first lactation ($c1$)
- Parameter c for the second lactation ($c2$)
- Parameter c for the third and higher lactations ($c3$)
- Parameter d for the first lactation ($d1$)
- Parameter d for the second lactation ($d2$)
- Parameter d for the third and higher lactations ($d3$)

4.3.7 Input file INPUT23.TXT

This file includes economic, management and biological input parameters. Equal values of the parameters are expected for both progeny groups (dairy and cross-bred progeny). Some data for slaughter weight refer to the beef breed which is used for crossing. If a difference occurs, insert the weighted average of the two values (weighted by the number of progeny in both groups). Inputs referring to castrates are skipped when reading data if there are no castrates in the system. Similarly, inputs for fattened bulls or heifers are skipped, if there is no fattening of bulls or heifers, respectively, in the system. The parameters are:

- Coefficient for price decrease for heifers involuntarily culled (ratio between the price per kg carcass of involuntarily culled heifers and the price per kg carcass of heifers that reached target slaughter weight, $kpr[12]$)
- Coefficient for price decrease for bulls involuntarily culled (ratio between the price per kg carcass of involuntarily culled bulls and the price per kg carcass of bulls that reached target slaughter weight, $kpr[14]$)
- Coefficient for price decrease for castrates involuntarily culled (ratio between the price per kg carcass of involuntarily culled castrates and the price per kg carcass of castrates that reached target slaughter weight, $kpr[17]$)
- Dressing proportion of heifers not reaching target slaughter weight as proportion of dressing proportion of heifers reaching target slaughter weight ($kdresh$)
- Dressing proportion of bulls not reaching target slaughter weight as proportion of dressing proportion of bulls reaching target slaughter weight ($kdresb$)
- Dressing proportion of castrates not reaching target slaughter weight as proportion of dressing proportion of castrates reaching target slaughter weight ($kdresc$)
- Price per kg carcass of heifers in the base class for carcass grading[31] (prh)
- Price per kg carcass of bulls in the base class for carcass grading[32] (prb)
- Price per kg carcass of castrates in the base class for carcass grading[33] ($prcs$)

[31] The "base" class will mostly but not necessarily be the best class. The prices for all other classes are then calculated by multiplying the price of the base class with a coefficient. These coefficients will be given in the input file INPUT24.TXT on the next page. The price coefficient for the "base" class or "reference" class is naturally 1.

[32] see footnote 31

[33] see footnote 31

- Number of commercial classes for fleshiness ($p1$)
- Number of commercial classes for fat covering ($p2$)
- Slaughter weight of pure-bred beef bulls at the end of fattening ($wbfatb$)
- Slaughter weight of pure-bred beef heifers at the end of fattening ($whfatb$)
- Slaughter weight of pure-bred beef castrates at the end of fattening ($wcfatb$)
- Slaughter weight of pure-bred dairy heifers at the end of fattening ($whfat[0]$)
- Slaughter weight of pure-bred dairy bulls at the end of fattening ($wbfat[0]$)
- Slaughter weight of pure-bred dairy castrates at the end of fattening ($wcfat[0]$)

4.3.8 Input file INPUT24.TXT

In its first part, this input file contains matrices describing the distribution of the pure-bred dairy progeny over the individual commercial classes for fleshiness and fat covering. In the second part, the file contains the matrices of coefficients of carcass prices which are valid both for pure-bred and cross-bred animals. Please notice that the description of the given matrix is posted *under* the matrix. The rows represent the commercial classes for fleshiness, the columns the classes for fat covering. The numbers of rows and columns of all matrices must be in accordance with the appropriate parameters in INPUT23.TXT. The matrices of coefficients of carcass prices show the ratio of the price per kg carcass in the given class to the price in the base class. The price of the base class is an input parameter in the input files INPUT11.TXT and INPUT23.TXT (see Sections 4.3.2 and 4.3.7, respectively). Inputs referring to castrates are skipped when reading data if there are no castrates in the system. Similarly, inputs referring to bulls are skipped if there is no fattening of bulls. Inputs for heifers and cows are always needed.

The matrices are as follows:

- Matrix $\mathbf{Pb_p}$: proportions of bull carcasses in commercial classes for fleshiness and fat covering ($Pb[j][i][0]$)
- Matrix $\mathbf{Ph_p}$: proportions of heifer carcasses in commercial classes for fleshiness and fat covering ($Ph[j][i][0]$)
- Matrix $\mathbf{Pcs_p}$: proportions of castrate carcasses in commercial classes for fleshiness and fat covering ($Pcs[j][i][0]$)
- Matrix $\mathbf{Pc_p}$: proportions of cow carcasses in commercial classes for fleshiness and fat covering ($Pc[j][i][0]$)
- Matrix **Prb**: coefficients of carcass prices in commercial classes for fleshiness and fat covering for bulls relative to the base class (insert value 1 for the base class) ($Prb[j][i]$)
- Matrix **Prh**: coefficients of carcass prices in commercial classes for fleshiness and fat covering for heifers relative to the base class (insert value 1 for the base class) ($Prh[j][i]$)
- Matrix **Prcs**: coefficients of carcass prices in commercial classes for fleshiness and fat covering for castrates relative to the base class (insert value 1 for the base class) ($Prcs[j][i]$)

- Matrix **Prc**: coefficients of carcass prices in commercial classes for fleshiness and fat covering for cows relative to the base class (insert value 1 for the base class) ($Prc[j][i]$)

See example in Section 4.2.12 on page 83.

4.3.9 Input file INPUT25.TXT

This input file contains matrices describing the distribution of the cross-bred (beef × dairy) progeny over the individual commercial classes for fleshiness and fat covering. The file is only read if there is crossbreeding in the system and if cross-bred animals are fattened, otherwise it is ignored. The matrices have the same structure as in input file INPUT24.TXT (see Section 4.3.8). Inputs referring to castrates are skipped when reading data if there are no castrates in the system. Similarly, the inputs for cross-bred bulls and heifers are skipped if there is no fattening of bulls or heifers, respectively, in the system.

The matrices are as follows:

- Matrix $\mathbf{Pb_c}$ - proportions of bull carcasses in commercial classes for fleshiness and fat covering ($Pb[j][i][1]$)
- Matrix $\mathbf{Ph_c}$ - proportions of heifer carcasses in commercial classes for fleshiness and fat covering ($Ph[j][i][1]$)
- Matrix $\mathbf{Pcs_c}$ - proportions of castrate carcasses in commercial classes for fleshiness and fat covering ($Pcs[j][i][1]$)

4.3.10 Input file INPUT27.TXT

This file contains the input parameters for gene flow (see Section 2.8). The parameter 'Number of age classes for cross-bred dams' depends on the number of reproductive cycles in program EWBC. Modify this parameter in the appropriate way if necessary.

The parameters in the file are:

- Number of age classes for dairy sires ($acsd$)
- Number of age classes for dairy dams ($LL - 1+$ age at calving in years[34]) ($acdd$)
- Number of age classes for beef sires[35] ($acsb$).
- Number of age classes for cross-bred dams (Calculate as: Number of reproductive cycles in System 3 + age at calving in years[36] - 1) ($acdc$). This input is skipped if there is no connection with Production System 3.
- Number of the sex-age class for which the gene flow will be calculated (n_sac)
- Length of the investment period (l_inv)
- Proportion of genes from individual age classes of dairy sires in male progeny (path sires to sires, the numbers must sum to 0.5) ($PM[i][j]$, $i = acsb+acdd+1$, $j = acsb + acdd + 1, \ldots, acsb + acdd + acsd$)

[34] When calculating the age in years, round always up to the next full year. For example, 1.1 years should be rounded up to 2 years etc.

[35] This and the following input are read only in systems with cross-breeding.

[36] See footnote 34.

- Proportion of genes from individual age classes of dairy sires in female progeny (path sires to dams, the numbers must sum to 0.5) ($PM[i][j]$, $i = acsb + 1$, $j = acsb + acdd + 1, \ldots, acsb + acdd + acsd$)
- Proportion of genes from individual age classes of dairy dams in male progeny (path dames to sires, the numbers must sum to 0.5) ($PM[i][j]$, $i = acsb + acdd + 1$, $j = acsb + 1, \ldots, acsb + acdd$)
- Proportion of genes from individual age classes of beef sires in cross-bred progeny (the numbers must sum to 0.5)[37] ($PM[i][j]$, $i = acsb+acdd+acsd+1$, $j = 1, \ldots, acsb$)

4.3.11 Input file INPUT28.TXT

This file contains parameters which are needed for the calculation of the milk price. According to the option for the calculation of the milk price (see Paragraph 4.1.1.15), different sets of parameters are read. The value of the parameters which are not read in the given run is of no impact on the results; they can be simply ignored. The parameters mainly refer to fat and protein content in milk and to somatic cell count (SCC) or somatic cell score. Furthermore, milk coagulation properties (rennet coagulation time and curd firmness) may be considered. A great variety of pricing systems can be parametrised by this file. The following input parameters are to be specified in dependence of the parameter *milkprice*, the option for the calculation of the milk price (see Paragraph 4.1.1.15):

Part A

- Base price for milk (*prmilkb*). This is the milk price not taking into account the fat and protein content, somatic cell score and milk coagulation properties. Its value is read for $milkprice = 1, 3$ or 5. The base price for milk is set to zero if $milkprice = 2$ or 4.

Part B The following part of the input file (until the next comment commencing with "/*") is read only if the option for the calculation of the milk price (*milkprice*) takes one of the following values: 3, 4 or 5.

- Parameter $nfat$ for the dependence of the milk price on milk fat content. Insert -1 if the milk price does not depend on fat content. Insert 0 if the milk price depends linearly over the whole range on fat content (there is only one regression equation). Insert a positive integer (number of threshold values) if the dependence changes at one or more values (threshold values) of the fat content.
- Threshold values for milk fat ($thfat[i]$). If $nfat$ takes values -1 or 0 insert zero. If $nfat > 0$ insert $nfat$ threshold values.
- Parameter *nprot* for the dependence of the milk price on the milk protein content. Insert -1 if the milk price does not depend on protein content. Insert 0 if the milk price depends linearly over the whole range on protein content (there is only one regression equation). Insert a positive integer (number of threshold values) if the dependence changes at one or more values (threshold values) of the protein content.
- Threshold values for milk protein ($thprot[i]$). If *nprot* takes values -1 or 0 insert zero. If $nprot > 0$ insert *nprot* threshold values.

[37] This input is read only in systems with cross-breeding.

- Constants (intercepts), regression coefficients and reference values for fat content in individual classes ($rf[i][j]$). The whole range of the fat content is divided by the $nfat$ threshold values into $nfat+1$ classes where the first class is the range between 0% and the first threshold value, the second class in the range between the first and the second threshold value, ..., and the last class is the range between the last threshold value and 100%. For all classes (rows in the matrix), three numbers have to be given. The first number b_0 is a constant (intercept). The second number b_1 is the regression coefficient. The third number x_r is a reference value which is subtracted from the fat content. The regression equation has therefore the following form:

$$y = b_0 + b_1(x - x_r) \tag{4.1}$$

  where x is the milk fat content and y is the value which is to be added[38] to the base milk price.

- Constants (intercepts), regression coefficients and reference values for protein content in individual classes ($rp[i][j]$). See explanations above.

- Phenotypic standard deviation for milk fat content ($sigmafat$)

- Phenotypic standard deviation for milk protein content ($sigmaprot$)

Part C The next part of the input file is read only if the option for the calculation of the milk price ($milkprice$) takes one of the following values: 2, 4 or 5.

- Mean of somatic cell score in the dairy cow population ($mSCS$)

- Phenotypic standard deviation of somatic cell score in the dairy cow population ($sigmaSCS$)

- Number of milk quality classes according to somatic cell count ($nSCC$, this value is automatically set to 1 for $milkprice = 1$ or 3)

- Upper limits for somatic cell count in the individual milk quality classes ($tSCC[i]$, the 1st class being the best)

Part D The following vector of parameters is read for $milkprice = 2$ or 4:

- Vector of base prices per kg milk in quality class i ($prSCC[i]$, $i = 0$ to $nSCC-1$ where $nSCC$ is the number of milk quality classes according to somatic cell count)

Part E This matrix of parameters is read only for $milkprice = 5$:

- Multiplicative and additive adjustment factors for milk quality classes on the basis of SCC ($facSCC[i]$ and $prSCC[i]$, respectively). Two parameters must be given for each milk quality class. The first one is used to multiply the milk price calculated before and the second parameter is added to the milk price. For more details see Section 2.5.1.2 and the following examples.

[38] The value of y may also be negative so that the resulting milk price may be lower than the base milk price.

Part F Part F is to be filled in only if data on rennet coagulation time and/or curd firmness are available and $milkprice = 3, 4$ or 5.

- Average curd firmness ($a30$)
- Phenotypic standard deviation for curd firmness ($sigmaa30$)
- Average rennet coagulation time (RCT)
- Phenotypic standard deviation for rennet coagulation time ($sigmaRCT$)
- Parameter for the dependence of the milk price on curd firmness ($na30$). Insert one of the following values:
  - -1 if the milk price is independent of curd firmness
  - 0 if the milk price depends linearly over the whole range of curd firmness
  - an integer > 0 if the milk price depends piecewise on curd firmness; the integer is the number of threshold values (values of curd firmness where the dependence changes)
- Threshold values for curd firmness ($tha30[i]$, $i = 0, \ldots, na30$). If $na30$ takes values -1 or 0 insert zero. If $na30 > 0$ insert $na30$ threshold values.
- Constants (intercepts), regression coefficients and reference values for curd firmness in individual classes ($ra30[i][j]$). For further details see explanation for milk fat content in Part B.
- Parameter for the dependence of the milk price on rennet coagulation time ($nRCT$). Insert one of the following values:
  - -1 if the milk price is independent of rennet coagulation time
  - 0 if the milk price depends linearly over the whole range of rennet coagulation time
  - an integer > 0 if the milk price depends piecewise on rennet coagulation time; the integer is the number of threshold values (values of rennet coagulation time where the dependence changes)
- Threshold values for rennet coagulation time ($thRCT[i]$, $i = 0, \ldots, nRCT$). If $nRCT$ takes values -1 or 0 insert zero. If $nRCT > 0$ insert $nRCT$ threshold values.
- Constants (intercepts), regression coefficients and reference values for rennet coagulation time in individual classes ($rRCT[i][j]$). For further details see explanation for milk fat content in Part B.

Some examples will be given. Example 1 refers to Part A of the input file, examples 2 to 5 refer to Part B of the input file. Examples 6, 7 and 8 are for Parts C, D and E, respectively. Examples 9 to 11 refer to Part F.

4.3.11.1 Example 1 for INPUT28.TXT for filling in Part A of the input file

Assume that the milk price does neither depend on the somatic cell count nor on the protein content, fat content, rennet coagulation time and curd firmness. That means, the option for the calculation of the milk price ($milkprice$) is 1 in PARAD.TXT. Then the only parameter read from the file is the base milk price ($prmilkb$). That means, only Part A of the file is relevant:

```
/* Input parameters for program EWDC (Production System 4):
Parameters for the calculation of the milk price.
For examples see the Manual.
MU: monetary unit */
0.324
"Base price for milk (is read if the option for the calculation of the milk price
takes one of the following values:  1, 3 or 5; for details see the manual.)"
"MU/kg"
```

The rest of the input file is ignored and it does not matter how it looks like.

4.3.11.2 Example 2 for INPUT28.TXT for filling in Part B of the input file

This is an example for modelling the dependence of the milk price on the fat and/or protein content. It is relevant if the option for the calculation of the milk price[39] (variable *milkprice*) takes one of the following values: 3, 4 or 5.

The pricing system looks as follows: There is a penalty of 0.04 MU (monetary unit) if the fat content is below 3.6%. This penalty does not depend on the fat content. Only the base milk price[40] is paid if the fat content is between 3.6% and 3.9%.

For the fat content greater than 3.9%, 0.02 MU are paid for each additional per cent. That means, the parameter for the dependence of the milk price on the milk fat content takes the value 2 (two threshold values, 3.6% and 3.9%). There are three classes for regression with the following equations:

$$\begin{aligned} y &= -0.04 + 0(x - 0) = -0.04 \\ y &= 0 + 0(x - 0) = 0 \\ y &= 0 + 0.02(x - 3.9) = 0.02(x - 3.9) \end{aligned} \tag{4.2}$$

Therefore, in the first class, $b_0 = -0.04$, $b_1 = 0$ and $x_r = 0$. In the second class, all three parameters are zero and in the third class, $b_0 = 0$, $b_1 = 0.02$ and $x_r = 3.9$.

In a similar way, there is a penalty of 0.04 MU if the protein content is below 2.8%. Only the base milk price is paid if the protein content is between 2.8% and 3.3%. For the protein content greater than 3.3%, 0.02 MU are paid for each additional per cent. That means, the parameter for the dependence of the milk price on the milk protein content takes also the value 2 and there are three classes for regression. The equations are similar as for fat content. In the first class, $b_0 = -0.04$, $b_1 = 0$ and $x_r = 0$. In the second class, all three parameters are zero and in the third class, $b_0 = 0$, $b_1 = 0.02$ and $x_r = 3.3$.

The standard deviations for fat and protein content are 0.45 and 0.213, respectively. Then the relevant part of the input file looks as follows:

```
/* Input parameters for program EWDC (Production System 4):
...  */
...
/* ...  */
2
"Parameter for the dependence of the milk price on the milk fat content..."
" "
3.6 3.9
"Threshold values for milk fat..."
"%"
2
"Parameter for the dependence of the milk price on the milk protein content ..."
" "
```

[39] See Paragraph 4.1.1.15 on page 59.

[40] The base milk price is the first input parameter in INPUT28.TXT (*milkprice* = 3 or 5) or is calculated from the prices of the individual milk quality classes (*milkprice* = 4).

```
2.8 3.3
"Threshold values for milk protein..."
"%"
-0.04 0 0
0 0 0
0 0.02 3.9
"Constants (intercepts), regression coefficients and reference values for fat content
in individual classes"
"MU/% fat"
-0.04 0 0
0 0 0
0 0.02 3.3
"Constants (intercepts), regression coefficients and reference values for protein con-
tent in individual classes"
"MU/% protein"
0.45
"Standard deviation for milk fat content"
"%"
0.213
"Standard deviation for milk protein content"
"%"
...
```

4.3.11.3 Example 3 for INPUT28.TXT for filling in Part B of the input file

This is a second example for modelling the dependence of the milk price on the fat and/or protein content. It is relevant if the option for the calculation of the milk price[41] (variable *milkprice*) takes one of the following values: 3, 4 or 5.

Assume that there is a base milk price[42] paid for milk carrier (milk without fat and protein).

For each per cent of milk fat, 0.056 MU is paid and for each per cent of milk protein, 0.090 MU is paid. Both for fat and protein content, the regression is over the whole range and there is no threshold value. The regression equation for fat content is:

$$y = 0 + 0.056(x - 0) = 0.056x \tag{4.3}$$

Therefore, $b_0 = 0$, $b_1 = 0.056$ and $x_r = 0$. For protein content we get

$$y = 0 + 0.090(x - 0) = 0.090x \tag{4.4}$$

so that $b_0 = 0$, $b_1 = 0.090$ and $x_r = 0$.

The appropriate part of the input file looks therefore as follows:

```
/* ...  */
...
/* ...  */
0
"Parameter for the dependence of the milk price on the milk fat content ..."
" "
0
"Threshold values for milk fat ..."
"%"
0
"Parameter for the dependence of the milk price on the milk protein content ..."
" "
0
"Threshold values for milk protein ..."
"%"
0 0.056 0
"Constants (intercepts), regression coefficients and reference values for fat content
in individual classes"
```

[41] See Paragraph 4.1.1.15 on page 59.
[42] See footnote 40 on the previous page.

```
"MU/% fat"
0 0.090 0
"Constants (intercepts), regression coefficients and reference values for protein con-
tent in individual classes"
"MU/% protein"
0.45
"Standard deviation for milk fat content"
"%"
0.213
"Standard deviation for milk protein content"
"%"
...
```

4.3.11.4 Example 4 for INPUT28.TXT for filling in Part B of the input file

This is a third example for modelling the dependence of the milk price on the fat and/or protein content. It is relevant if the option for the calculation of the milk price[43] (variable *milkprice*) takes one of the following values: 3, 4 or 5.

There is a base milk price[44] paid for milk with given fat (4.2%) and protein (3.4%) content. For fat content greater than 4.2%, 0.046 MU is paid for each additional per cent, for fat content lower than 4.2%, the same value is subtracted from the base price for each per cent. For protein content greater than 3.4%, 0.063 MU is paid for each additional per cent, for protein content lower than 3.4%, the same value is subtracted from the base price for each per cent. There is again only one class for regression. The regression equation for fat content is:

$$y = 0 + 0.046(x - 4.2) = 0.046(x - 4.2) \tag{4.5}$$

so that $b_0 = 0$, $b_1 = 0.046$ and $x_r = 4.2$. For protein content we get

$$y = 0 + 0.063(x - 3.4) = 0.063(x - 3.4) \tag{4.6}$$

that means $b_0 = 0$, $b_1 = 0.063$ and $x_r = 3.4$.
The relevant part of the input file looks therefore as follows:

```
/* ... */
...
/* ... */
0
"Parameter for the dependence of the milk price on the milk fat content ..."
" "
0
"Threshold values for milk fat ..."
"%"
0
"Parameter for the dependence of the milk price on the milk protein content ..."
" "
0
"Threshold values for milk protein ..."
"%"
0 0.046 4.2
"Constants (intercepts), regression coefficients and reference values for fat content
in individual classes"
"MU/% fat"
0 0.063 3.4
"Constants (intercepts), regression coefficients and reference values for protein con-
tent in individual classes"
"MU/% protein"
0.45
"Standard deviation for milk fat content"
```

[43] See Paragraph 4.1.1.15 on page 59.
[44] See footnote 40 on page 105.

```
"%"
0.213
"Standard deviation for milk protein content"
"%"
...
```

4.3.11.5 Example 5 for INPUT28.TXT for filling in Part B of the input file

This is the last example for modelling the dependence of the milk price on the fat and/or protein content. It is relevant if the option for the calculation of the milk price[45] (variable *milkprice*) takes one of the following values: 3, 4 or 5.

In this example, there is a penalty of 0.004 MU per per cent of fat content below 3.8%. If fat content is between 3.8 and 4.5%, a bonus of 0.004 MU per percent of fat is paid. For fat content greater than 4.5% no bonus is paid (milk price with fat content above 4.5% is the same as the price for milk with 4.5% fat). This system may be described by one threshold value (4.5%). The payment below and above 3.8% fat (until 4.5% fat) can be described by the following equation:

$$y = 0 + 0.004(x - 3.8) = 0.004(x - 3.8) \tag{4.7}$$

so that $b_0 = 0$, $b_1 = 0.004$ and $x_r = 3.8$. From this equation we calculate for $x = 4.5$ a value of $y = 0.004(4.5 - 3.8) = 0.0028$. Therefore, for a fat content greater than the threshold value 4.5% we get the second regression equation as

$$y = 0.0028 + 0(x - 0) = 0.0028 \tag{4.8}$$

That means that $b_0 = 0.0028$, $b_1 = 0$ and $x_r = 0$.

For milk with a protein content of 3.2%, the base milk price is paid[46]. For each per cent of protein above this value, additional 0.031 MU are paid; for each per cent of protein below this value, the same penalty is subtracted. Therefore, for protein no threshold value is given and the regression is over the whole interval of protein content:

$$y = 0 + 0.031(x - 3.2) = 0.031(x - 3.2) \tag{4.9}$$

so that $b_0 = 0$, $b_1 = 0.031$ and $x_r = 3.2$.

The appropriate part of input file INPUT28.TXT is then:

```
/* ...  */
...
/* ...  */
1
"Parameter for the dependence of the milk price on the milk fat content ..."
" "
4.5
"Threshold values for milk fat ..."
"%"
0
"Parameter for the dependence of the milk price on the milk protein content ..."
" "
0
"Threshold values for milk protein ..."
"%"
0 0.004 3.8
0.0028 0 0
```

[45] See footnote 43.

[46] The base milk price is the first input parameter in INPUT28.TXT (*milkprice* = 3 or 5) or is calculated from the prices of the individual milk quality classes (*milkprice* = 4).

```
"Constants (intercepts), regression coefficients and reference values for fat content
in individual classes"
"MU/% fat"
0 0.031 3.2
"Constants (intercepts), regression coefficients and reference values for protein con-
tent in individual classes"
"MU/% protein"
0.45
"Standard deviation for milk fat content"
"%"
0.213
"Standard deviation for milk protein content"
"%"
...
```

4.3.11.6 Example 6 for INPUT28.TXT for filling in part C of the input file

This part of the input file is read if the option for the calculation of the milk price[47] (variable *milkprice*) takes one of the following values: 2, 4 or 5. The text of the input file should be sufficiently self-explanatory. Just a short comment. If the number of classes for somatic cell count is 4 then there are $4 - 1 = 3$ boundaries between the classes. Therefore, the upper limits are given only for classes 1 to 3.

```
/* The following part of the input file until the next comment is read only if the
option for the calculation of the milk price takes one of the following values:  2, 4
or 5.  For details see the manual.  */
4.51765
"Mean of somatic cell score in the dairy cow population"
" "
0.23529
"Phenotypic standard deviation of somatic cell score in the dairy cow population"
" "
4
"Number of milk quality classes according to somatic cell content"
" "
250000 400000 600000
"Upper limits for somatic cell count in the individual milk quality classes (the 1st
class being the best)"
"Number of somatic cells/ml milk"
```

4.3.11.7 Example 7 for INPUT28.TXT for filling in part D of the input file

This part of the input file is read if the option for the calculation of the milk price[48] (variable *milkprice*) is 2 or 4. The number of values given is identical to the number of classes for somatic cell count defined in Part C of the input file. For four classes, Part D looks like that:

```
/* The vector of base prices is read only if the option for the calculation of the
milk price takes one of the following values:  2 or 4.  For details see the manual.  */
0.328 0.324 0.092 0.040
"Vector of base prices per kg milk in quality class i (i=0 to nSCC-1 where nSCC is
the number of milk quality classes according to somatic cell count)"
"MU/kg"
```

4.3.11.8 Example 8 for INPUT28.TXT for filling in part E of the input file

This part of the input file is read if the option for the calculation of the milk price[49] (variable *milkprice*) is 5. In the example, four milk quality classes on the basis of

[47] See Paragraph 4.1.1.15 on page 59.
[48] See footnote 47
[49] see footnote 47

somatic cell count are assumed. The first class is always assumed to be the best. Assume that the base milk price was read and corrected for fat and/or protein content. This value be 0.326 MU[50]/kg. In the first class, it is assumed that 0.002 MU/kg were added to this price. That means, the multiplicative coefficient is 1 and the additive adjustment factor is 0.002. The milk price in this class is then: $1 \cdot 0.326 + 0.002 = 0.328$ MU/kg. In the second class, no correction is assumed, i.e. the multiplicative adjustment factor is 1 and the additive adjustment factor is 0. The final milk price is therefore calculated as $1 \cdot 0.326 + 0 = 0.326$ MU/kg. In the third and the forth classes, 30% and 10%, respectively, of the original price are payed. The multiplicative adjustment factors are therefore 0.3 and 0.1, respectively. The milk price in these classes is $0.3 \cdot 0.326 + 0 = 0.0978$ MU/kg or $0.1 \cdot 0.326 + 0 = 0.0326$ MU/kg, respectively. The part of the input file looks then as follows:

```
/* The adjustment factors are read only if the option for the calculation of the milk
price takes the value 5.  For details see the manual.  */
1.0   0.002
1.0   0.0
0.3   0.0
0.1   0.0
"Multiplicative and additive adjustment factors for milk quality classes on the basis
of SCC"
"-   MU/kg"
```

See also Paragraph 2.5.1.2.5 on page 31 for further examples.

4.3.11.9 Example 9 for INPUT28.TXT for filling in Part F of the input file

Examples 9 to 11 model the dependence of the milk price on curd firmness and rennet coagulation time. They are relevant if the option for the calculation of the milk price[51] (variable *milkprice*) takes one of the following values: 3, 4 or 5. Furthermore, in the parameter file PARAD.TXT (see Section 4.1.3 on page 61) it must be indicated that data for curd firmness and/or rennet coagulation time are available ($ind\_a30 = 1$, $ind\_RCT = 1$).

The pricing system according to the milk coagulation properties looks as follows: For curd firmness grater than 26 mm, 0.00033 MU is paid for each additional mm, for curd firmness lower than 26 mm until 5 mm, the same value is subtracted from the base price for each mm. For curd firmness lower than 5 mm a penalty of 0.07 MU is subtracted from the base price. There is one threshold value, 5 mm. There are two classes for regression with the following equations:

$$\begin{aligned} y &= -0.07 + 0(x - 0) = -0.07 \qquad \text{for } x < 5 \\ y &= 0 + 0.00033(x - 26) = 0.00033(x - 26) \qquad \text{for } x \geq 5 \end{aligned} \tag{4.10}$$

Therefore, in the first class, $b_0 = -0.07$, $b_1 = 0$ and $x_r = 0$. In the second class, $b_0 = 0$, $b_1 = 0.00033$ and $x_r = 26$.

Similarly, for rennet coagulation time less than 18 minutes, 0.00066 MU is paid for each minute under 18 minutes and for rennet coagulation time greater than 18 minutes until 28 minutes, the same value (0.00066 MU) is subtracted from the base price for each minute. For rennet coagulation time higher than 28 min, a penalty of 0.07 MU is subtracted from the base price. The parameter for the dependence of the milk price on rennet coagulation time takes the value 1 (one threshold value, 28 min). There are two classes for regression with the following equations:

$$\begin{aligned} y &= 0 - 0.00066(x - 18) = -0.00066(x - 18) \qquad \text{for } x \leq 28 \\ y &= -0.07 + 0(x - 0) = -0.07 \qquad \text{for } x > 28 \end{aligned} \tag{4.11}$$

[50] monetary units

[51] See Paragraph 4.1.1.15 on page 59.

Therefore, in the first class, $b_0 = 0$, $b_1 = -0.00066$ and $x_r = 18$. In the second class $b_0 = -0.07$, $b_1 = 0$ and $x_r = 0$.

The average curd firmness and the phenotypic standard deviation are 32 mm and 6.5 mm, respectively. The average rennet coagulation time and the phenotypic standard deviations are assumed to be 16.9 min and 4.5 min, respectively. Then the relevant part of the input file looks as follows:

```
...
/* The following two values are read only if data for curd firmness are available.  */
32
"Average curd firmness"
"mm"
6.5
"Phenotypic standard deviation for curd firmness"
"mm"
/* The following two values are read only if data for rennet coagulation
  time are available.  */
16.9
"Average rennet coagulation time"
"min"
4.5
"Phenotypic standard deviation for rennet coagulation time"
"min"
/* The following values are read only if data for curd firmness are
  available and if the option for calculating the milk price is > 2.  */
1
"Parameter for the dependence of the milk price on curd firmness.  ..."
" "
5
"Threshold value(s) for curd firmness (the number of values is given by
  the parameter above)."
"mm"
-0.07 0 0
0 0.00033 26
"Constants (intercepts), regression coefficients and reference
  values for curd firmness in individual classes"
"MU MU/mm mm"
/* The following values are read only if data for rennet
  coagulation time are available and if the option for
  calculating the milk price is > 2.  */
1
"Parameter for the dependence of the milk price on rennet coagulation time.  ..."
" "
28
"Threshold value(s) for rennet coagulation time (the number
  of values is given by the parameter above)."
"min"
0 -0.00066 18
-0.07 0 0
"Constants (intercepts), regression coefficients and reference
  values for rennet coagulation time in individual classes"
"MU MU/mm mm"
```

4.3.11.10 Example 10 for INPUT28.TXT for filling in Part F of the input file

No dependency of the milk price on curd firmness is assumed. Therefore in the parameter file PARAD.TXT (see Section 4.1.3 on page 61) it should be indicated that data for curd firmness are not available ($ind\_a30 = 0$). For rennet coagulation time less than 18 minutes, a bonus of 0.00066 MU is paid for each minute, for rennet coagulation time greater than 18 minutes the same value (0.00066 MU) is subtracted from the base price for each minute.

There is only one class for regression. For rennet coagulation time we get

$$y = 0 - 0.00066(x - 18) = -0.00066(x - 18) \tag{4.12}$$

that means $b_0 = 0$, $b_1 = -0.00066$ and $x_r = 18$.

The average and standard deviation for rennet coagulation time is the same as in Example 9. Zeros may be inserted for all values referring to curd firmness.

Then the relevant part of the input file looks as follows:

```
/* The following two values are read only if data for curd firmness are
available.  */
0
"Average curd firmness"
"mm"
0
"Phenotypic standard deviation for curd firmness"
"mm"
/* The following two values are read only if data for rennet coagulation
  time are available.  */
16.9
"Average rennet coagulation time"
"min"
4.5
"Phenotypic standard deviation for rennet coagulation time"
"min"
/* The following values are read only if data for curd firmness are
available and if the option for calculating the milk price is > 2.  */
-1
"Parameter for the dependence of the milk price on curd firmness.  ..."
" "
0
"Threshold value(s) for curd firmness (...)."
"mm"
0
"Constants (intercepts), regression coefficients and reference
  values for curd firmness in individual classes"
"MU MU/mm mm"
/* The following values are read only if data for rennet
  coagulation time are available and if the option for
  calculating the milk price is > 2.  */
0
"Parameter for the dependence of the milk price on rennet coagulation time.  ..."
" "
0
"Threshold value(s) for rennet coagulation time (...)."
"min"
0 -0.00066 18
"Constants (intercepts), regression coefficients and reference
  values for rennet coagulation time in individual classes"
"MU MU/mm mm"
```

4.3.11.11 Example 11 for INPUT28.TXT for filling in Part F of the input file

The same conditions as in Example 9 must be fulfilled: the option for the calculation of the milk price[52] (variable *milkprice*) is 3, 4 or 5 and data on curd firmness and rennet coagulation time must be are available ($ind\_a30 = 1$, $ind\_RCT = 1$).

For curd firmness grater than 26 mm, 0.00033 MU is paid for each additional mm, for curd firmness lower than 26 mm, the same value is subtracted from the base price for each mm. That means, there is only one class for regression with the following equation:

$$y = 0 + 0.00033(x - 26) = 0.00033(x - 26) \tag{4.13}$$

Therefore $b_0 = 0$, $b_1 = 0.00033$ and $x_r = 26$.

Similarly, for rennet coagulation time less than 18 minutes, 0.00066 MU is paid for each minute under 18 minutes, for rennet coagulation time greater than 18

[52] See Paragraph 4.1.1.15 on page 59.

minutes, the same value is subtracted from the base price for each minute. There is only one class for regression which can be described by the following equation:

$$y = 0 - 0.00066(x - 18) = -0.00066(x - 18) \tag{4.14}$$

so that $b_0 = 0$, $b_1 = -0.00066$ and $x_r = 18$.

The average curd firmness and the phenotypic standard deviation are 32 mm and 6.5 mm, respectively. The average rennet coagulation time and the phenotypic standard deviation are 16.9 min and 4.5 min, respectively. Then the relevant part of the input file looks as follows:

```
/* The following two values are read only if data for curd firmness are
available.  */
32
"Average curd firmness"
"mm"
6.5
"Phenotypic standard deviation for curd firmness"
"mm"
/* The following two values are read only if data for rennet coagulation
time are available.  */
16.9
"Average rennet coagulation time"
"min"
4.5
"Phenotypic standard deviation for rennet coagulation time"
"min"
/* The following values are read only if data for curd firmness are
available and if the option for calculating the milk price is > 2.  */
0
"Parameter for the dependence of the milk price on curd firmness..."
" "
0
"Threshold value(s) for curd firmness (...)."
"mm"
0 0.00033 26
"Constants (intercepts), regression coefficients and reference
values for curd firmness in individual classes"
"MU MU/mm mm"
/* The following values are read only if data for rennet
coagulation time are available and if the option for
calculating the milk price is > 2.  */
0
"Parameter for the dependence of the milk price on rennet coagulation time ..."
" "
0
"Threshold value(s) for rennet coagulation time (the number
of values is given by the parameter above)."
"min"
0 -0.00066 18
"Constants (intercepts), regression coefficients and reference
values for rennet coagulation time in individual classes"
"MU MU/mm mm"
```

4.3.12 Input file INPUT29.TXT

This file contains input parameters for the calculation of cost due to clinical mastitis (CM) in the cow herd. It is necessary only if the economic weight for clinical mastitis is to be calculated (option 1 for 'Data for mastitis incidence' in parameter file PARAD.TXT - see Section 4.1.3 on page 61). The parameters in the file are:

- Cost for drugs per average CM case (*costdrug*)
- Veterinarian's time spend per average CM case (*labvet*)

- Average charge for veterinary service (*pricevet*)
- Herdsman's time dealing with an average CM case (treatment, separate milking etc.) (*labherd*)
- Value of herdsman's time (*priceherd*)
- Depreciation cost for a separate milking machine per year and per ill cow (*costmach*)
- Price per dose of drug for drying cows (*pricedry*)
- Proportion of cows that are dried with antibiotics per calving interval (*pdry*)
- Vector of incidence rate of CM (number of CM cases) per cow-year at risk in lactations 1 to LL ($ircmy[i]$)

4.3.13 Input file INPUT30.TXT

This file contains the daily mastitis incidence (number of cows having mastitis divided by the total number of cows at the given day) for days 1 to 400 of 1st, 2nd and 3rd and subsequent lactations. The first number in each row is the day of lactation ($i1$), the following three numbers are the mastitis incidence for the 1st, 2nd and 3rd and subsequent lactations, respectively ($dmi[j][i]$ with $i = i1 - 1$ and $j = 0, 1, 2$, i.e. j is the lactation number minus 1). The file is necessary only if the economic weight for clinical mastitis is to be calculated (option 1 for 'Data for mastitis incidence' in parameter file PARAD.TXT - see Section 4.1.3 on page 61).

4.3.14 Input file INPUT31.TXT

In this file, you are asked to choose between two alternative definitions of the same trait. The two definitions are presented with the number of the traits (as given in Appendix A.2) in parentheses. Type the number of the definition you prefer.

The following selections are to be made (the variable to which the numbers are read is given in parentheses):

- Select (32) milk fat in per cent or (33) milk fat in kg per 305 days of lactation ($flag[1]$)
- Select (34) milk protein in per cent or (35) milk protein in kg per 305 days of lactation ($flag[2]$)
- Select (11) cow losses in per cent or (29) productive lifetime of cows in years ($flag[3]$)

The traits 40 and 41 cannot be chosen if there is a connection between the dairy system and the beef Production System 3.

- Select (12) conception rate of heifers or (40) interval between 1st mating and conception in heifers ($flag[7]$)
- Select (13) conception rate of cows or (41) calving interval in cows ($flag[8]$)

4.3.15 Input file INPUT32.TXT

This file is necessary if genetic standard deviations are known for the direct and maternal components of the traits[53]. It contains input parameters (genetic standard deviations) for calculating the relative economic weights of traits. If there are direct and maternal components of a trait two input values are to be given, otherwise only one value is given. Keep attention that the genetic standard deviations are given in correct units. The genetic standard deviations must be for the breed the economic weights are calculated for (see Paragraph 4.1.1.13 on page 58). The selection of traits is given by the parameters in the parameter file PARAD.TXT (see Subsection 4.1.3 on page 61) and in input file INPUT31.TXT (see Subsection 4.3.14 on the preceding page). On this basis, the appropriate input is skipped if the trait is not considered in the calculation. The individual inputs are:

- Genetic standard deviations for direct and maternal components of calving performance score
- Genetic standard deviations for direct and maternal components of losses of calves at calving
- Genetic standard deviations for direct and maternal components of losses of calves from 48 hours after calving till the end of rearing
- Genetic standard deviation for mature weight
- Genetic standard deviations for direct and maternal components of birth weight
- Genetic standard deviations for direct and maternal components of average daily gain of calves from birth to 1st weighing in System 3
- Genetic standard deviations for direct and maternal components of average daily gain of calves from 1st to 2nd weighing in System 3
- Genetic standard deviations for direct and maternal components of average daily gain of calves from 2nd to 3rd weighing in System 3
- Genetic standard deviation for daily gain in fattening
- Genetic standard deviation for dressing percentage
- Genetic standard deviation for cow losses
- Genetic standard deviation for conception rate of heifers
- Genetic standard deviation for conception rate of cows
- Genetic standard deviation for mean class of fleshiness
- Genetic standard deviation for mean class of fat covering
- Genetic standard deviations for direct and maternal components of weight gain of calves from birth to 1st weighing in System 3
- Genetic standard deviations for direct and maternal components of weight gain of calves from 1st to 2nd weighing in System 3
- Genetic standard deviations for direct and maternal components of weight gain of calves from 2nd to 3rd weighing in System 3

[53] That is, the option for reading genetic standard deviations in PARAD.TXT must be 2 (see Paragraph 4.1.1.17).

- Genetic standard deviation for lifetime of cows
- Genetic standard deviations for direct and maternal components of daily gain of calves from birth to the end of rearing period
- Genetic standard deviation for 305d milk production
- Genetic standard deviation for fat content in milk
- Genetic standard deviation for fat yield in 305d-lactation
- Genetic standard deviation for protein content in milk
- Genetic standard deviation for protein yield in 305d-lactation
- Genetic standard deviation for somatic cell score
- Genetic standard deviation for mastitis incidence in the herd
- Genetic standard deviation for rennet coagulation time
- Genetic standard deviation for curd firmness
- Genetic standard deviation for the interval between the 1st mating and conception of heifers
- Genetic standard deviation for calving interval
- Genetic standard deviation for daily residual dry matter intake in calves
- Genetic standard deviation for daily residual dry matter intake in heifers
- Genetic standard deviation for daily residual dry matter intake in fattening
- Genetic standard deviation for daily residual dry matter intake in cows
- Genetic standard deviation for claw disease incidence in the herd
- Genetic standard deviation for dry matter intake in extensive fattening in System 3

The genetic standard deviations for the direct and maternal components of the traits are read to the vectors $gstd\_d[i]$ and $gstd\_m[i]$, respectively, where i is the number of trait according to Appendix A.2.

4.3.16 Input file INPUT33.TXT

This file is necessary if genetic standard deviations of the traits are known and are not differentiated between direct and maternal components[54]. It is read only if there is no cross-breeding in the herd or if there is terminal crossing. It contains input parameters (genetic standard deviations) for calculating the standardised marginal economic values of traits. Keep attention that the genetic standard deviations are given in the correct units. The genetic standard deviations must be for the breed the economic values are calculated for. The selection of traits is given by the parameters in the parameter file PARAD.TXT (see Subsection 4.1.3 on page 61) and in input file INPUT31.TXT (see Subsection 4.3.14 on page 114). On this basis, the appropriate input is skipped if the trait is not considered in the calculation.

The genetic standard deviations are read for the same traits as in INPUT32.TXT. They are read to the vector $gstd\_d[i]$ where i is the number of the trait according to Appendix A.2.

[54] That is, the option for reading genetic standard deviations in PARAD.TXT must be 3 (see Paragraph 4.1.1.17).

4.3.17 Input file INPUT37.TXT

The file is only needed if the economic value for claw disease incidence is to be calculated. It contains the following input parameters for the calculation of cost due to claw diseases in the cow herd:

- Average cost for drugs per claw disease case treated with antibiotics (*costacd*)
- Average veterinarian's time spent per antibiotic treatment of claw disease (*labvetcd*)
- Average charge for veterinary service (*prvetcd*)
- Cost for drugs per claw disease case not treated with antibiotics (*costnacd*)
- Average herdman's (or trimmer) time dealing with an average claw disease case (both antibiotic treatment and treatment without antibiotics, *labherdcd*)
- Value of herdman's (or trimmer) time (*prherdcd*)
- Vector of the total incidence rate of claw diseases per cow-year at risk in lactation 1 to LL (in the whole calving interval, $ircdy[i]$)
- Number of claw diseases treated with antibiotics (veterinarian treatments) as proportion of all claw diseases per cow-year at risk in lactation 1 to LL (in the whole calving interval, $pacd[i]$)

4.3.18 Input file INPUT38.TXT

The file is only needed if the economic value for claw disease incidence is to be calculated. It contains the daily claw disease incidence (number of cows having claw disease **which must be treated with antibiotics** divided by the total number of cows at the given day) for days 1 to 400 of 1st, 2nd and 3rd and subsequent lactations.

The first number in each row is the day of lactation, the following three numbers are the antibiotically treated claw disease incidences for the 1st, 2nd and 3rd and subsequent lactations, respectively. The daily values of claw disease incidence are read to $dcdi[i][j]$.

4.3.19 Input file FROM1_3.TXT

This file is produced by program EWBC (see Section 5.1.3 on page 120). It is necessary if there is a connection between the dairy system and a production system of type 3. In this case, Production System 3 has to be calculated with program EWBC before running program EWDC. File FROM1_3.TXT must be copied to the directory of EWDC if EWBC is not in the same directory as EWDC.

4.3.20 Input file T.TXT

This file is produced by program EWBC. It is necessary if there is a connection between the dairy system and a production system of type 3. In this case, Production System 3 has to be calculated with program EWBC before running program EWDC. Before starting EWDC, file T.TXT must be in the same directory as EWDC. T.TXT is described as output file of EWBC (see Subsection 5.1.4 on page 120).

4.4 TEXT_OUT.TXT and TEXTD_OUT.TXT: files containing text for writing results

These files contain texts which are used for printing the results. They contain headings of sections of the results files, comments and names of variables the values of which are printed in the results files. For editing the files read carefully the remarks at the beginning of Section 4 on page 55. The file TEXT_OUT.TXT is needed for Production Systems 1 to 3 (program EWBC) and the file TEXTD_OUT.TXT is necessary for Production System 4 (program EWDC).

Chapter 5

Program output

5.1 Output files for Production Systems 1 to 3 (program EWBC)

5.1.1 The results file

The name of the file the results are written to is determined by the user when starting the program. The first part of the file contains the following information:

- Version of the program, copyright and contact to the authors
- System variables (read from PARA.TXT, see Section 4.1.2)
- Input parameters read from the individual input files

The second part contains the following results:

- Structure of the cow herd in the stationary state
- Reproduction characteristics of the herd
- Growth of cows in reproductive cycles 1 to 3
- Characteristics of progeny born in the herd
- Mean classes for flashiness, fat covering and calving performance score
- Nutrition cost
- Further cost components and total costs per animal in each category
- Cost for dystocia
- Revenues
- Number of discounted expressions (covering only one generation of offspring where heifers are included till calving) for revenues and costs of all categories of cattle per cow and year
- Profit
- Marginal economic values for all traits
- Economic weights for direct and maternal components for the selection group chosen
- Relative economic weights (optional)
- Relative marginal economic values (optional)

Remark. Printing results is controlled by many conditions which are specific for the given calculation. Nevertheless because of the large number of input parameters and possible conditions, it cannot be fully excluded that some values are printed which have no relevance for the given calculation. Just ignore them and inform the authors to further improve the program in this point.

5.1.2 File CHECK

This file is of importance mainly for people who are interested in a further development of the program. The file lists the values of all variables (except some index variables and temporary variables) used in the program. The file can be useful for finding bugs in the program. A good way of checking the program was to calculate two versions of economic values - one for a change of 0.5% down and upwards in the trait (variables $ew[i]$) and a second one for a change of 1% to both sides in the trait (variables $ew0[i]$). The difference between these two numbers expressed in per cent ($ewdiff[i]$) should be reasonably low, generally less than one per cent. However, greater values may occur when the absolute value of the economic value is small.

5.1.3 File FROM1_3.TXT

This file is needed for Production System 4 (program EWDC) if

- there is cross-breeding in the system (first parameter in PARAD.TXT must be 1) and
- if cross-bred heifers are sold to Production System 3 as replacement (parameter "Utilization of cross-bred female calves which are not needed for replacement" must have value 3 in PARAD.TXT).

It contains the following information on Production System 3:

- A short comment.
- The number of the Production System ($prodsys2$, see Section 4.1.1.1). This must be always 3.
- The number of reproductive cycles (LL in program EWBC, read as $L3$ in program EWDC)
- Total conception rate of heifers in a mating period ($crh1mp$ in EWBC, read as $tconh3$ in EWDC)
- Vector **l3** (LL elements: cows calving in reproductive cycles 1 to LL expressed as proportion of cows entering any reproductive cycle); these data are read to the corresponding elements of the gene transmission matrix for gene flow $PM[i][j]$ in EWDC.
- Vector **ew** (economic values, 33 elements, see numbering of traits in the Appendix on page 127). The values are read in as $(ew[i][2])$ with $i = 1, ..., 29$, 43, 44, 47, 45.

5.1.4 File T.TXT

This file is needed for Production System 4 (program EWDC) if

- there is cross-breeding in the system (first parameter in PARAD.TXT must be 1) and

- if cross-bred heifers are sold to Production System 3 as replacement (parameter "Utilization of cross-bred female calves which are not needed for replacement" must have value 3 in PARAD.TXT).

It connects information on the selection of traits between the beef and the dairy system. It contains the following variables: $flag[1]$ to $flag[4]$ which are read as $flag[4]$, $flag[5]$, $flag[6]$ and $flag[3]$, respectively by EWDC. Furthermore, the file contains the variables $to[30]$ to $to[33]$ which are read as $to3[43]$, $to3[44]$, $to3[47]$ and $to3[45]$, respectively, by EWDC.

5.2 Output files for Production System 4 (program EWDC)

5.2.1 The results file

The name of the file the results are written to is determined by the user when starting the program. The first part of the file contains the following information:

- Version of the program, copyright and contact to the authors
- System variables (read from PARAD.TXT, see Section 4.1.3)
- Input parameters read from the individual input files

The second part contains the following results:

- Structure of the cow herd in the stationary state
- Reproductive characteristics of the herd
- Growth of cows in reproductive cycles 1 to 3
- Characteristics of progeny born in the herd
- Mean classes for flashiness, fat covering and calving performance score
- Nutrition cost
- Cost per animal in each category
- Cost for dystocia
- Revenues
- Number of discounted expressions for revenues and costs for all categories of cattle per cow per year (covering only one generation of progeny, where heifers are included till calving)
- Profit
- Marginal economic values
- Economic weights for direct and maternal components for the selection group chosen
- Relative economic weights (optional)
- Relative marginal economic values (optional)

Remark. See remark at the end of Section 5.1.1 on page 119.

5.2.2 File CHECKD

This file is of importance mainly for people who are interested in a further development of the program. The file lists the values of all variables (except some index variables and temporary variables) used in the program.

5.2.3 File CHECKDhelp

As CHECKD, this file is of importance mainly for people who are interested in a further development of the program. The file lists the values of all variables (except some index variables and temporary variables) used in the program before starting the calculation of economic weights.

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Appendix A

Lists of traits and of variables in EWBC and EWDC

A.1 Some useful comments

Indices in the program are used in different manners for distinct arrays. The index variable referring to the reproductive cycle is always identical with the number of the reproductive cycle decremented by one; reproductive cycles 1 to LL are represented by the values 0 to $LL-1$ of the appropriate index variable. The same principle is applied to most cases when the dimension is less or equal to 10. In arrays with higher dimension, the value of the index variable in the program is, as a rule, identical to its real value; the index used for the category of animals in the program, for example, is always identical with the numbers given in the manual in Section 2.2.2. When the index for the category of animals is calculated from the number of the reproductive cycle (symbol r is used in these cases) the real number of the reproductive cycle as given in Section 2.2.1 is to be inserted.

Proportions are usually understood as fractions. Deviations from this general principle are specified in the description of the variable (in some cases, proportions are given as percentage).

For finding possible bugs in the program, the economic values are calculated twice. The values calculated as described in Section 2.7 and printed to the results file will be found in the vector $ew[i]$ for Program EWBC and in the vector $ew[i][j]$ for Program EWDC. For each trait a second value is calculated by shifting the value of the trait by twice the value it was shifted for $ew[i]$ or $ew[i][j]$, respectively. These latter values will be found in the vectors $ew0[i]$ or $ew0[i][j]$, respectively. If the program works well, the difference between these two values given in the vector $ewdiff[i]$ or $ewdiff[i][j]$, respectively, in per cent should be small, to our experience mostly 1% or less. Nevertheless, in some traits where the profit depends strongly non-linearly on the trait value or the absolute value of the economic value is small, the difference may be somewhat greater (2 to 3%). Large differences may occur when the economic value is near zero. In this case the principle of relative differences does not make sense. But, if the economic values are "sufficiently" far from zero and you will observe greater values for these differences (all these values are printed in the files CHECK or CHECKD - see Sections 5.1.2 or 5.2.2, respectively), something is probably going wrong. Inform please the authors of the program in this case.

A.2 Numbering of traits

The following numbering of traits is used:

A.2.1 Programs EWBC and EWDC

1	Average score for calving performance (male and female calves together)
2	Losses of calves at calving
3	Losses of calves from 48 hours till weaning or till the end of the rearing period
4	Mature weight of cows
5	Birth weight of calves
6	Average daily gain of calves from birth to 1st weighing
7	Average daily gain of calves from 1st to 2nd weighing
8	Average daily gain of calves from 2nd to 3rd weighing
9	Average daily gain in the fattening period to constant slaughter weight
10	Dressing percentage
11	Cow losses
12	Conception rate of heifers
13	Conception rate of cows
14	Mean class of fleshiness for cows
15	Mean class of fleshiness for bulls
16	Mean class of fleshiness for heifers
17	Mean class of fleshiness for castrates
18	Mean class of fleshiness for all categories together
19	Mean class of fat covering for cows
20	Mean class of fat covering for bulls
21	Mean class of fat covering for heifers
22	Mean class of fat covering for castrates
23	Mean class of fat covering for all categories together
24	Average score for calving performance (female calves)
25	Average score for calving performance (male calves)
26	Weight gain of calves from birth to 1st weighing
27	Weight gain of calves from 1st to 2nd weighing
28	Weight gain of calves from 2nd to 3rd weighing
29	Average lifetime of cows

A.2.2 Program EWBC

30 Residual daily dry matter intake of heifers in rearing (trait 43 in EWDC)

31 Residual daily dry matter intake of animals in intensive fattening (trait 44 in EWDC)

32 Residual daily dry matter intake of animals in extensive fattening (trait 47 in EWDC)

33 Residual daily dry matter intake of adult animals (trait 45 in EWDC)

A.2.3 Program EWDC

30 Average daily gain from birth till the end of the rearing period

31 305d milk production

32 Fat percentage

33 305d fat yield (kg)

34 Protein percentage

35 305d protein yield (kg)

36 Somatic cell score

37 Mastitis incidence

38 Rennet coagulation time

39 Curd firmness

40 Average interval between first mating and conception in heifers

41 Average calving interval of cows

42 Residual daily dry matter intake of calves in rearing

43 Residual daily dry matter intake of heifers in rearing (trait 30 in EWBC)

44 Residual daily dry matter intake of animals in fattening (trait 31 in EWBC)

45 Residual daily dry matter intake of cows (trait 33 in EWBC)

46 Incidence for claw disease

47 Residual daily dry matter intake of animals in extensive fattening (trait 32 in EWBC)

In the program EWBC, economic weights for traits 1 - 33 are calculated. The economic weights for traits 14 - 17, 19 - 22 and 24 - 25 are not printed to the results file. For traits 9, 10, 12, 18, 23 and 30 - 32, only the economic weights for the direct component of the traits are considered and printed whereas for traits 4, 11, 13, 29 and 33 only the economic weights for the maternal component are printed. For the remaining traits (1 - 3, 5 - 8, 26 - 28), the economic weights are calculated and printed both for the direct and the maternal components of the traits.

In the program EWDC, economic weights for traits 1 - 47 are calculated. Here also the economic weights for traits 14 - 17, 19 - 22 and 24 - 25 are not printed to the results file. For traits 9, 10, 12, 18, 23, 40, 42 - 44 and 47 only the economic

weights for the direct component of the traits are considered and printed whereas for traits 4, 11, 13, 29, 31 - 39, 41, 45 and 46 only the economic weights for the maternal component are printed. For the remaining traits (1 - 3, 5 - 8, 26 - 28 and 30), the economic weights are calculated and printed both for the direct and the maternal components of the traits.

A.3 List of variables

a — Temporary variable

a1 — Program EWBC: Temporary variable (e.g. convergence criterion for iteration). Program EWDC: Parameter a in the lactation curve for the 1st lactation[1]

a2 — Program EWBC: Parameter a in the lactation curve (see equation (2.4) in Section 2.3) for two year old cows. Program EWDC: Parameter a in the lactation curve for the 2nd and higher lactations[2]

a3 — Program EWBC: Parameter a in the lactation curve for three year old cows[3]. Program EWDC: Temporary variable

a4 — Program EWBC: Parameter a in the lactation curve for four year old cows[4]

a9 — Temporary variable

a30 — Program EWDC: curd firmness

aa1 — Temporary variable

aa2 — Temporary variable

aa3 — Temporary variable

aa4 — Temporary variable

aa5 — Temporary variable

aa6 — Temporary variable

aa11 — Temporary variable

ab[i] — Probability of abortion for cows conceived in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

ACD — Program EWBC: Maximal number of age classes for dams (set to 30)

acd — Program EWBC: Number of age classes for dams calculated as $LL -$ 1+age at calving in years (rounded up to the next integer)

ACDC — Program EWDC: Maximal number of age classes for cross-bred dams (set to 25)

acdc — Program EWDC: Number of age classes for cross-bred dams calculated as: Number of reproductive cycles in System 3 + age at calving in years (rounded up to the next integer) - 1

[1] See Section 2.3 for the lactation curves and for the derivation of their parameters
[2] see footnote 1
[3] see footnote 1
[4] see footnote 1

ACDD Program EWDC: Maximal number of age classes for dairy dams (set to 20)

acdd Program EWDC: Number of age classes for dairy dams ($LL - 1+$ age at calving in years)

ACM Maximal dimension of the matrix for gene flow (set to 60 in EWBC and to 90 in EWDC)

acm Dimension of matrix **PM** (transmission matrix for gene-flow)

ACS Program EWBC: Maximal number of age classes for sires (set to 25)

acs Number of age classes for sires

ACSB Program EWDC: Maximal number of age classes for beef sires (set to 20)

acsb Program EWDC: Number of age classes for beef sires

ACSD Program EWDC: Maximal number of age classes for dairy sires (set to 20)

acsd Program EWDC: Number of age classes for dairy sires

addry[i] Program EWBC: Actual daily dry matter intake of category i ($i = 1, \ldots, CC$)

addrybbs Program EWBC: Actual daily dry matter intake of breeding bulls in the herd in the summer feeding period

addrybbw Program EWBC: Actual daily dry matter intake of breeding bulls in the herd in the winter feeding period

addryfas[i] Program EWBC: Actual daily dry matter intake of category i of extensivelly fattened animals in the last feeding period after pasture

addrys[i] Program EWBC: Actual daily dry matter intake of category i in the summer period ($i = 1, \ldots, CC$)

addryt Program EWBC: Actual daily dry matter intake of breeding bulls in performance test (only for production system 1)

addrytb Program EWBC: Actual daily dry matter intake of breeding bulls from weaning to the beginning of the performance test (only for production system 1)

addrytse Program EWBC: Actual daily dry matter intake of breeding bulls from the end of performance test till selling (only for production system 1)

addryw[i] Program EWBC: Actual daily dry matter intake of category i in the winter period ($i = 1, \ldots, CC$)

adg[i] Average daily gain of category i (Program EWBC: $i = 1, ..., CC + 10$, Program EWDC: $i = 1, ..., CT$)

adg10 Program EWDC: Daily gain of bulls from the end of the rearing period of calves till selling

adg1cow Program EWDC: Average daily gain of cows in the 1st reproductive cycle

adg2cow Program EWDC: Average daily gain of cows in the 2nd reproductive cycle

adgbbt Program EWBC: Daily gain of bulls in test

adgcf[i] Program EWDC: Daily gain of female calves in the rearing period ($i = 0$ for pure-bred animals, $i = 1$ for cross-bred animals)

adgcm[i] Program EWDC: Daily gain of male calves in the rearing period ($i = 0$ for pure-bred animals, $i = 1$ for cross-bred animals)

adgcon1f Program EWBC: Average daily gain of females from birth to the first control weighing

adgcon1m Program EWBC: Average daily gain of males from birth to the first control weighing

adgcon2f Program EWBC: Average daily gain of females from the first to the second control weighing

adgcon2m Program EWBC: Average daily gain of males from the first to the second control weighing

adgcon3f Program EWBC: Average daily gain of females from the second to the third control weighing

adgcon3m Program EWBC: Average daily gain of males from the second to the third control weighing

adgfrep Program EWBC: Average daily gain (without foetus) from purchase of a breeding heifer to calving

adgh1s Program EWBC: Daily gain of replacement heifers in the 1st summer season after their weaning

adgh2s Program EWBC: Daily gain of replacement heifers in the 2nd summer season after their weaning

adgh2w Program EWBC: Daily gain of replacement heifers in the 2nd winter season after their weaning

adgh3s Program EWBC: Daily gain of replacement heifers in the 3rd summer season after their weaning

adgh3w Program EWBC: Daily gain of replacement heifers in the 3rd winter season after their weaning

adgh4w Program EWBC: Daily gain of replacement heifers in the 4th winter season after their weaning

adghcal Program EWBC: Average daily gain of heifers from weaning to the 1st calving (without gain for foetus - average of heifers conceived in all 3 mating periods after weaning)

adghmc[i] Program EWDC: Daily gain of replacement heifers from the 1st mating to calving (without foetus) ($i = 0$ for pure-bred animals, $i = 1$ for cross-bred animals)

adghm[i] Program EWDC: Daily gain of replacement heifers from the end of rearing period to the 1st mating ($i = 0$ for pure-bred animals, $i = 1$ for cross-bred animals)

adgs0[i] Program EWBC: Average daily gain in the "zeroth" summer period[5] after weaning for category i

adgs1[i] Program EWBC: Average daily gain in the 1st summer period after weaning for category i

adgs2[i] Program EWBC: Average daily gain in the 2nd summer period after weaning for category i

adgs3[i] Program EWBC: Average daily gain in the 3rd summer period after weaning for category i

adgst Program EWBC: Average daily gain from weaning to the start of the bull test in category 10

adgtm Program EWBC: Average daily gain of bulls from the test end to reaching mature weight

adgw[i] Program EWBC: Average daily gain in the winter period after weaning for category i

adgw1[i] Program EWBC: Average daily gain in the 1st winter period after weaning for category i

adgw2[i] Program EWBC: Average daily gain in the 2nd winter period after weaning for category i

adgw3[i] Program EWBC: Average daily gain in the 3rd winter period after weaning for category i

adgw4 Program EWBC: Average daily gain in the 4th winter period after weaning for category

adgwsc Program EWBC: Daily gain of castrates in intensive fattening

adgwsc[i] Program EWDC: Daily gain of pure-bred ($i = 0$) and cross-bred ($i = 1$) castrates in intensive fattening

adgwsf Program EWBC: Daily gain of heifers in intensive fattening

adgwsf[i] Program EWDC: Daily gain of pure-bred ($i = 0$) and cross-bred ($i = 1$) heifers in intensive fattening

adgwsm Program EWBC: Daily gain of bulls in intensive fattening

adgwsm[i] Program EWDC: Daily gain of pure-bred ($i = 0$) and cross-bred ($i = 1$) bulls in intensive fattening

adgwt Program EWBC: Average daily gain of bulls in test (category 10)

age[i] Program EWDC: Age of animals in category i ($i = 1, \ldots, CT$)

agebbcull Program EWBC: Age of breeding bulls at culling

agebbm Program EWBC: Age of breeding bulls when reaching mature body weight

agebbse Program EWBC: Age of breeding bulls at purchase for the herd or at purchase to A.I. centres

[5] This period occurs only if calves are weaned before the end of the pasture period.

agebbst Program EWBC: Average age of breeding bulls at the begin of the performance test

agebbt Program EWBC: Average age of breeding bulls at the end of the performance test

agec1[i] Program EWDC: Age of calves at the end of the first feeding period during rearing ($i = 0$ for pure-bred animals, $i = 1$ for cross-bred animals)

agecal Program EWBC: Age of cows at first calving

agecwsc Program EWBC: Average age of castrates culled in the fattening period before reaching target slaughter weight

agecwsc[i] Program EWDC: Average age of of pure-bred ($i = 0$) and cross-bred ($i = 1$) castrates culled in the fattening period before reaching target slaughter weight

agecwsf Program EWBC: Average age of heifers culled in the fattening period before reaching target slaughter weight

agecwsf[i] Program EWDC: Average age of pure-bred ($i = 0$) and cross-bred ($i = 1$) heifers culled in the fattening period before reaching target slaughter weight

agecwsm Program EWBC: Average age of bulls culled in the fattening period before reaching target slaughter weight

agecwsm[i] Program EWDC: Average age of pure-bred ($i = 0$) and cross-bred ($i = 1$) bulls culled in the fattening period before reaching target slaughter weight

agedcw Program EWBC: Average age of calves died from 2 days of age to weaning

agedcw[i] Program EWDC: Average age of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves died from 2 days of age to the end of the rearing period

agedmh Program EWBC: Average age of breeding heifers died from weaning to entering the herd

agedmh[i] Program EWDC: Average age of breeding pure-bred ($i = 0$) and cross-bred ($i = 1$) heifers died from the end of the rearing period to entering the herd

agedwsc Program EWBC: Average age of castrates died in the fattening period

agedwsc[i] Program EWDC: Average age of pure-bred ($i = 0$) and cross-bred ($i = 1$) castrates died in the fattening period

agedwsf Program EWBC: Average age of heifers died in the fattening period

agedwsf[i] Program EWDC: Average age of pure-bred ($i = 0$) and cross-bred ($i = 1$) heifers died in the fattening period

agedwsm Program EWBC: Average age of bulls died in the fattening period

agedwsm[i] Program EWDC: Average age of pure-bred ($i = 0$) and cross-bred ($i = 1$) bulls died in the fattening period

agefrep Program EWBC: Age of females for replacement at purchase

ageh1cal Program EWBC: Average age at calving for heifers conceived in the 1st mating period after weaning

ageh1cal[0] Program EWDC: Average age of pure-bred heifers at calving

ageh2cal Program EWBC: Average age at calving for heifers conceived in their 2nd mating period after weaning

ageh3cal Program EWBC: Average age at calving for heifers conceived in their 3rd mating period after weaning

agehcmat Program EWBC: Average age of heifers culled after the 1st, 2nd and 3rd mating periods after weaning because of no pregnancy

agehcmat1 Program EWBC: Average age of heifers culled after their 1st mating period after weaning because of no pregnancy

agehcmat1[0] Program EWDC: Average age of pure-bred heifers culled after their mating period because of no pregnancy

agehcmat2 Program EWBC: Average age of heifers culled after their 2nd mating period after weaning because of no pregnancy

agehcmat3 Program EWBC: Average age of heifers culled after their 3rd mating period after weaning because of no pregnancy

agehmat Program EWBC: Average age of heifers at mating (weighted average from all 3 mating periods)

agehmat1 Program EWBC: Average age at mating for heifers mated in their 1st mating period after weaning.

agehmat1[i] Program EWDC: Average age of heifers at their 1st mating (1st insemination) ($i = 0$ for pure-bred heifers, $i = 1$ for cross-bred heifers)

agehmat2 Program EWBC: Average age at mating for heifers mated in their 2nd mating period after weaning

agehmat3 Program EWBC: Average age at mating for heifers mated in their 3rd mating period after weaning

agesc Program EWBC: Average age of castrates at the end of the fattening period

agesc[i] Program EWDC: Average age of pure-bred ($i = 0$) and cross-bred ($i = 1$) castrates at the end of the fattening period

agesf Program EWBC: Average age of heifers at the end of the fattening period

agesf[i] Program EWDC: Average age of pure-bred ($i = 0$) and cross-bred ($i = 1$) heifers at the end of the fattening period

agesm Program EWBC: Average age of bulls at the end of the fattening period

agesm[i] Program EWDC: Average age of pure-bred ($i = 0$) and cross-bred ($i = 1$) bulls at the end of the fattening period

agew Program EWBC: Average age of calves at weaning

agew[i] Program EWDC: Average age of pure-bred ($i = 0$) and cross-bred ($i = 1$) calves at the end of rearing period

aic	Program EWBC: Proportion of insemination in cows
aih	Program EWBC: Heifers inseminated (or mated) in 1st oestrus within the mating period as proportion of heifers available for breeding. If there is no insemination, it is assumed that all heifers are naturally mated and aih is set to 1.
aihc	Program EWBC: Heifers pregnant in their 1st oestrus within the given mating period as proportion of all heifers which entered this mating period
am	Program EWBC: Parameter a in the lactation curve for cows older than four years[6]
anphse	Program EWBC: Average age of non-mated breeding heifers at selling
anphse1	Program EWBC: Average age of non-mated breeding heifers sold before the first mating period after their weaning
anphse2	Program EWBC: Average age of non-mated breeding heifers sold between the first and second mating period after their weaning
aphse	Program EWBC: Average age of pregnant breeding heifers at selling
aphse1	Program EWBC: Average age of pregnant breeding heifers sold after the first mating period after their weaning
aphse2	Program EWBC: Average age of pregnant breeding heifers sold after the second mating period after their weaning
atdry[i]	Program EWBC: Actual total dry matter intake of category i ($i = 1, \ldots, CC$)
atdrybbs	Program EWBC: Actual total dry matter intake of breeding bulls in the herd in the summer feeding period
atdrybbw	Program EWBC: Actual total dry matter intake of breeding bulls in the herd in the winter feeding period
atdryfas[i]	Program EWBC: Actual total dry matter intake of category i of extensivelly fattened animals in the last feeding period after pasture
atdrys[i]	Program EWBC: Actual total dry matter intake of category i in the summer period ($i = 1, \ldots, CC$)
atdryt	Program EWBC: Actual total dry matter intake of breeding bulls in performance test (only for production system 1)
atdrytb	Program EWBC: Actual total dry matter intake of breeding bulls from weaning to the beginning of the performance test (only for production system 1)
atdrytse	Program EWBC: Actual total dry matter intake of breeding bulls from the end of performance test till selling (only for production system 1)
atdryw[i]	Program EWBC: Actual total dry matter intake of category i in the winter period ($i = 1, \ldots, CC$)

[6] See Section 2.3 for the lactation curves and for the derivation of their parameters

avecalc Program EWDC: Average number of cross-bred calvings in the herd per cow and reproductive cycle

avelifecc Program EWBC: Average productive life time of cows (in numbers of calvings)

avelifecl Program EWDC: Average productive lifetime of cows in number of lactations (not taking into account that some cows had shorter lactations due to culling or death during the reproductive cycle)

avelifecy Average productive life time of cows (in years)

avh Temporary variable used in the calculation of economic values of several traits

avl Temporary variable used in the calculation of economic values of several traits

b1 Program EWDC: Parameter b in the lactation curve for the 1st lactation[7]

b2 Program EWBC: Parameter b in the lactation curve for two year old cows. Program EWDC: Parameter b in the lactation curve for the 2nd lactation

b3 Program EWBC: Parameter b in the lactation curve for three year old cows. Program EWDC: Parameter b in the lactation curve for the 3rd and higher lactations

b4 Program EWBC: Parameter b in the lactation curve for four year old cows

b9 Temporary variable

bm Program EWBC: Parameter b in the lactation curve for cows older than 4 years

bw[i] Program EWBC: Average birth weight of calves (female calves ($i = 8$), male calves ($i = 9$), averaged over sexes ($i = 3$)). Program EWDC: Average birth weight of calves ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9$)

bwf Program EWBC: Weight of female calves at birth

bwf[i] Program EWDC: Weight of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves at birth

bwm Program EWBC: Weight of male calves at birth

bwm[i] Program EWDC: Weight of pure-bred ($i = 0$) and cross-bred ($i = 1$) male calves at birth

C Program EWBC: Maximal number of categories of animals + 1 (set to 143), Program EWDC: Total number of categories of animals + 1 (set to 137)

C1 Program EWDC: Total number of pure-bred categories of animals + 1 (set to 113)

[7] see footnote 6

c1 Program EWDC: Parameter c in the lactation curve for the 1st lactation[8]

c2 Program EWBC: Parameter c in the lactation curve for two year old cows. Program EWDC: Parameter c in the lactation curve for the 2nd lactation

c3 Program EWBC: Parameter c in the lactation curve for three year old cows. Program EWDC: Parameter c in the lactation curve for the 3rd and higher lactations

c4 Program EWBC: Parameter c in the lactation curve for four year old cows

c9 Temporary variable

cal[j][i] Program EWDC: Number of pure-bred ($j = 0$) and cross-bred ($j = 1$) calvings per cow and reproductive cycle $i + 1$ ($i = 0, ...LL - 1$)

calfloss Program EWBC: Total calf losses at calving (abort, stillbirth, death till 48 hours after calving)

calfloss[i] Program EWDC: Total calf losses at calving (abort, stillbirth, death till 48 hours after calving) for pure-bred ($i = 0$) and cross-bred ($i = 1$) calves

cast[i] Program EWDC: Option in PARAD.TXT: Pure-bred ($i = 0$) or cross-bred ($i = 1$) castrates are present in fattening $cast[i] = 1$ or not $cast[i] = 0$

cb Program EWDC: The parameter indicates if crossbreeding is used ($cb = 1$) or not ($cb = 0$)

CC Program EWBC: Number of categories of animals, $CC = 6(LL - 1) + 4 + 24 = TT + 24$. Program EWDC: Number of categories of animals if there is no crossbreeding

cculcm[i] Cows culled from calving to mating for health problems other than dystocia in reproductive cycle $i+1$ ($i = 0, ..., LL-1$) as proportion of cows entering the cycle

cculmc[i] Cows culled from mating to calving for health problems other than dystocia in reproductive cycle $i+1$ ($i = 0, ..., LL-1$) as proportion of cows entering the cycle

ciav Program EWDC: Average calving interval in the herd calculated only for the cows that entered the next reproductive cycle

ci[i] Program EWDC: Calving interval for reproductive cycle $i + 1$ ($i = 0, ...LL - 1$)

claw_inc Program EWDC: Indicator variable if economic value for claw disease is calculated or not

clcm[i] Cow losses from calving to mating for reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

clmc[i] Cow losses from mating to next calving for reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

[8] see footnote 6

cm — Program EWBC: Parameter c in the lactation curve for cows older than 4 years[9]

cmat[i] — Cows entering the mating period in reproductive cycle $i+1$ expressed as proportion of the number of cows at the beginning of this cycle ($i = 0, ..., LL-1$)

cmd — Culling rate of cows after dystocia (assumed to be equal in all reproductive cycles)

con_1 — Program EWBC: Age of calves at first weighing

con_2 — Program EWBC: Age of calves at second weighing

con_3 — Program EWBC: Age of calves at third weighing

conh[i] — Program EWDC: Heifers conceived after the ith insemination ($i = 0, ..., inmaxh$) as proportion of firstly inseminated heifers

conh1 — Program EWBC: Heifers conceived in the 1st mating period after their weaning expressed as proportion of all heifers which entered the 1st mating period

conh2 — Program EWBC: Heifers conceived in the 2nd mating period after their weaning expressed as proportion of all heifers which entered the 1st mating period

conh3 — Program EWBC: Heifers conceived in the 3rd mating period after their weaning expressed as proportion of all heifers which entered the 1st mating period

cost[i] — Vector of total cost for category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

costacd — Program EWDC: Average cost for drugs per claw disease case treated with antibiotics

costbb — Program EWBC: Total cost for a breeding bull for natural mating in the herd from purchase to slaughter

costc — Total costs per cow and year (averaged over all cow categories)

costcowy — Program EWBC: Average cost per cow and year in the cow-calf pasture system (including cost for replacement and dead calves without additional feeding costs for calves weaned) corrected for revenues from culled cows and heifers

costcw — Program EWBC: Average cost in the cow-calf pasture system per weaned calf without additional feeding cost for calf

costcwf — Program EWBC: Average cost in the cow-calf pasture system including additional feeding cost per weaned female calf

costcwfkg — Program EWBC: Average cost in the cow-calf pasture system per kg life weight of weaned female calves

costcwm — Program EWBC: Average cost in the cow-calf pasture system including additional feeding cost per weaned male calf

[9] See Section 2.3 for the lactation curves and for the derivation of their parameters

costcwmkg Program EWBC: Average cost in the cow-calf pasture system per kg life weight of weaned male calves

costd[i] Program EWDC: Cost for removing and rendering a dead mature animal of category i

costdc Program EWBC: Cost for removing and rendering a dead cow

costdcf[i] Program EWDC: Average cost for removing and rendering of a dead pure-bred ($i = 0$) or cross-bred ($i = 1$) calf in the rearing period

costdf Program EWBC: Cost for removing and rendering of a dead young animal (in fattening or rearing)

costdf[i] Program EWDC: Average cost for removing and rendering of a dead young pure-bred ($i = 0$) or cross-bred ($i = 1$) animal (replacement heifer or animal in fattening)

costdrug Program EWDC: Cost for drugs per average CM case

costdys Average cost of dystocia per cow and year

costdysc Program EWBC: Average cost of dystocia per calving

costf[i] Total cost for feeding (including water and minerals) per animal of category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

costfas[i] Program EWBC: Cost for feeding after extensive fattening on pasture if the required slaughter weight was not reached at the end of this fattening period, per animal of category i ($i = 5, 6, 12, 13, 16, 17$)

costfatb Program EWBC: Average cost in fattening per slaughtered bull reaching target slaughter weight (including costs for losses and culling for health, without costs for purchased weaned male calf for fattening)

costfatbkg Program EWBC: Average cost in fattening per kg carcass weight of bulls (without costs for purchased weaned male calf for fattening)

costfatc Program EWBC: Average cost in fattening per slaughtered castrate reaching target slaughter weight (including costs for losses and culling for health, without costs for purchased male calf for fattening)

costfatckg Program EWBC: Average cost in fattening per kg carcass weight of castrates (without costs for purchased weaned male calf for fattening)

costfath Program EWBC: Average cost in fattening per slaughtered heifer reaching target slaughter weight (including costs for losses and culling for health, without costs for purchased female calf for fattening)

costfathkg Program EWBC: Average cost in fattening per kg carcass weight of heifers (without costs for purchased weaned female calf for fattening)

costfbb Program EWBC: Total cost for feeding per breeding bull from purchase to slaughter

costfbbs Program EWBC: Cost for summer feeding per breeding bull from purchase to slaughter

costfbbw Program EWBC: Cost for winter feeding per breeding bull from purchase to slaughter

costfc Cost for feeding (including water and minerals) per cow and year (averaged over all cow categories)

costff[i] Program EWBC: Cost for feeding in intensive fattening per animal of category i ($i = 4, 5, 6, 12, 13, 14, 15, 16, 17$)

costfix[i] Fixed cost per animal of category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

costfixc Fixed cost per cow and year (averaged over all cow categories)

costfixwf[i] Program EWDC: Fixed cost in the rearing period per female calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

costfixwm[i] Program EWDC: Fixed cost in the rearing period per male calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

costfs[i] Program EWBC: Cost for summer feeding per animal of category i ($i = 1, ..., CC$ except $i = 4, 14, 15$)

costft Program EWBC: Cost for feeding per breeding bull in the performance test

costftb Program EWBC: Cost for feeding per breeding bull before the performance test

costftse Program EWBC: Cost for feeding per breeding bull from the end of the performance test to selling

costfw[i] Program EWBC: Cost for winter feeding per animal of category i ($i = 1, ..., CC$ except $i = 4, 14, 15$)

costfwf[i] Program EWDC: Cost for nutrition (food and water) in the rearing period per female calf ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

costfwm[i] Program EWDC: Cost for nutrition (food and water) in the rearing period per male calf ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

costh[i] Cost for housing (difference of cost for straw and revenues from dung) per animal of category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

costhbb Program EWBC: Cost for housing (difference of cost for straw and revenues from dung) per breeding bull in the herd from purchase to slaughter

costhc Cost for housing (difference of cost for straw and revenues from dung) per cow and year (averaged over all cow categories)

costhcd Program EWDC: Cost for drugs and herdman's labour for treatment of claw disease if no antibiotics are used, per cow and year

costhnpr Program EWBC: Average cost for breeding heifers sold to other systems before mating (including proportional cost per cow)

costhnprkg Program EWBC: Average cost per kg live weight of breeding heifers sold to other systems before mating (including proportional cost per cow)

costhpr Program EWBC: Average cost for pregnant breeding heifers sold to other systems (including proportional cost per cow)

costhprkg Program EWBC: Average cost per kg live weight of pregnant breeding heifers sold to other systems (including proportional cost per cow)

costhwf[i] Program EWDC: Cost for housing (difference of cost for straw and revenues from dung) in the rearing period per female calves ($i = 0$: purebred animals, $i = 1$: cross-bred animals)

costhwm[i] Program EWDC: Cost for housing (difference of cost for straw and revenues from dung) in the rearing period per male calves ($i = 0$: purebred animals, $i = 1$: cross-bred animals)

costi Program EWBC: Cost for breeding bulls (natural mating) per female and reproductive cycle

costi[i] Program EWDC: Cost for insemination per female of category i and per reproductive cycle

costimc Program EWBC: Cost for insemination and natural mating per cow and reproductive cycle

costimh Program EWBC: Cost for insemination and natural mating per heifer and mating period

costlab Cost per stock-man hour (needed for dystocia cost)

costlabm Program EWDC: Labour cost for herdsman's time dealing with CM per cow and year

costm[i] Program EWBC: Cost for minerals per animal of category i ($i = 1, ..., CC$ except $i = 4, 14, 15$)

costmach Program EWDC: Depreciation cost for a separate milking machine per year and per cow ill with clinical mastitis

costmbb Program EWBC: Cost for minerals per breeding bull from purchase to slaughter

costmilkv[i] Program EWDC: Part of variable costs for milk for category i ($i = NCP, ..., CC$)

costnacd Program EWDC: Average cost for durgs per claw disease case not treated with antibiotics

costo[i] Other cost in category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

costoc Other cost (breeding cost, cost for removing and rendering of dead cows) per cow and year (averaged over all cow categories)

costom Program EWDC: Other costs connected with clinical mastitis per cow and year

costv[i] Cost for veterinary treatment per animal of category i ($i = 1, ..., CC$), in program EWDC only defined for $i = 30$.

costvbb Program EWBC: Cost for veterinary treatment per breeding bull in the herd per reproductive cycle

costvbbt Program EWBC: Total veterinary cost per breeding bull in the herd from purchase to culling

costvet[i] Cost for veterinary treatment per animal of category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

costvet10 Program EWDC: Cost for veterinary treatment per bull from the end of the rearing period of calves till selling

costvetc Cost for veterinary treatment per cow and year (averaged over all cow categories)

costvetcd Program EWDC: Cost for drugs and veterinary service for antibiotic treatment of claw disease, per cow and year

costvetm Program EWDC: Cost for drugs and veterinary service for mastitis treatment, per cow and year

costvetwf[i] Program EWDC: Veterinary cost per female calf in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

costvetwm[i] Program EWDC: Veterinary cost per male calf in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

costvfi Program EWBC: Cost for veterinary treatment per animal in intensive fattening

costvfx Program EWBC: Cost for veterinary treatment per animal in extensive fattening

costwf[i] Program EWDC: Total cost per female calf in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

costwm[i] Program EWDC: Total cost per male calf in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

costwt[i] Cost for water per animal of category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

costwtbb Program EWBC: Cost for water per breeding bull from purchase to slaughter

costwwf[i] Program EWDC: Cost for water per female calf in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

costwwm[i] Program EWDC: Cost for water per male calf in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

cowb Program EWBC: Number of cows per bull for natural mating

cowyear Program EWDC: Number of stable places needed per cow and reproductive cycle

cp[i] Program EWBC: Total number of pregnant cows (weighted for cows with and without dystocia) in the mating period of reproductive cycle $i + 1$ ($i = 0, ..., LL - 2$) as proportion of cows calved in this cycle

cp2nm[i] Program EWBC: Probability that a cow (weighted average for cows with and without dystocia) not pregnant in the 1st oestrus will be pregnant in the 2nd oestrus within the mating period of reproductive cycle $i + 1$ ($i = 0, ..., LL - 2$)

cp3nm[i] Program EWBC: Probability that a cow (weighted average for cows with and without dystocia) not pregnant in the 2nd oestrus will be pregnant in the 3rd oestrus within the mating period of reproductive cycle $i+1$ $(i = 0, ..., LL-2)$

cpin[i] Program EWBC: Probability that a calved cow (weighted average for cows with and without dystocia) will be pregnant in the 1st oestrus in the mating period of reproductive cycle $i+1$ $(i = 0, ..., LL-2)$

cpin[i][j] Program EWDC: Probability that a calved cow in cycle $i+1$ $(i = 0, ..., LL-2)$ will be pregnant after insemination j $(j = 0, ..., inmax-1)$ (weighted average for cows with and without dystocia)

cpindys[i][j] Program EWDC: Cows having dystocia in reproductive cycle $i+1$ $(i = 0, ..., LL-1)$ and becoming pregnant after insemination j $(j = 0, ..., inmax-1)$ as proportion of all pregnant cows in reproductive cycle $i+1$.

cpinndys[i][j] Program EWDC: Cows without dystocia in reproductive cycle $i+1$ $(i = 0, ..., LL-1)$ becoming pregnant after insemination j $(j = 0, ..., inmax-1)$ as proportion of all pregnant cows in reproductive cycle $i+1$.

cr2nmh Program EWBC: Conception rate of heifers in the 2nd oestrus within a mating period expressed as proportion of heifers not being pregnant after the 1st oestrus in this mating period

cr3nmh Program EWBC: Conception rate of heifers in the 3rd oestrus within a mating period expressed as proportion of heifers not being pregnant after the 2nd oestrus in this mating period

crcmp[i] Program EWBC: Cows conceived after the mating period of reproductive cycle $i+1$ expressed as proportion of all mated cows in this cycle $(i = 0, ..., LL-2)$

crdys Average decrease in conception rate of cows caused by dystocia (average over all oestrus and reproductive cycles)

crh1mp Program EWBC: Total conception rate of heifers in a mating period

crhmp Program EWBC: Heifers conceived in one of the three mating periods after their weaning expressed as proportion of all heifers which entered the 1st mating period (only three subsequent mating periods are allowed for heifers after their weaning)

crinh Program EWBC: Conception rate of heifers in the 1st oestrus during the first part of the mating period expressed as proportion of heifers mated in this oestrus

crinh[i] Program EWDC: Conception rate of heifers after insemination i $(i = 0, ..., inmaxh-1)$

CT Program EWDC: Total number of animal categories $(CT = TT + 48)$

culh[i] Program EWDC: Vector of cows involuntarily culled within reproductive cycle $i+1$ $(i = 0, ..., LL-1)$ for other health problems than dystocia as proportion of cows which entered this reproductive cycle

culvol[i] Program EWDC: Vector of cows voluntarily culled within reproductive cycle $i+1$ ($i = 0, ..., LL-1$) for low milk production as proportion of cows which entered this reproductive cycle

D Maximal number of classes for calving performance (set to 6)

d[i] Days for which the costs per animal of category i are calculated (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

d1 Program EWDC: Parameter d for the lactation curve for the first lactation[10]

d1w[i] Program EWDC: Length of the first feeding period in the rearing period of calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

d2 Program EWDC: Program EWDC: Parameter d for the lactation curve for the second lactation

d3 Program EWDC: Parameter d for the lactation curve for the third and higher lactations

d9 Temporary variable

da Temporary variable

dasc Program EWBC: Days of feeding castrates after pasture in extensive fattening to reach the required slaughter weight

dasf Program EWBC: Days of feeding heifers after pasture in extensive fattening to reach the required slaughter weight

davcal Program EWBC: Average calving date for all females (heifers and cows) calving in the herd

davcalc Program EWBC: Average date of calving for cows in the herd

davcalh Program EWBC: Average date of calving for heifers in the herd

davmat Program EWBC: Average date of mating for all females (heifers and cows) in the herd

davmatc Program EWBC: Average date of mating for cows in the herd

davmath Program EWBC: Average date of the 1st mating for heifers in the herd

dayshc Program EWBC: Number of days from the average date of mating to the date of culling of barren heifers

dayshc[i] Program EWDC: Number of days from the average date of mating to the date of culling of barren pure-bred ($i = 0$) and cross-bred ($i = 1$) heifers

dayslac[i] Program EWDC: Length of the whole lactation in reproductive cycle $i+1$ ($i = 0, ..., LL-1$) (difference between the length of the calving interval and days dry)

dbb[i] Program EWBC: Number of days breeding bulls are kept in the herd (from purchase to culling)

dbpas Program EWBC: Date of beginning pasture

[10] See Section 2.3 for the lactation curves and for the derivation of their parameters

dc1[i] Program EWDC: Length of the first feeding period for a calf of category i ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9, CC + 10$)

dc2[i] Program EWDC: Length of the second period of feeding calves of category i ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9, CC + 10$)

dcalai Program EWBC: Average date of calving for females conceived in the 1st oestrus in the mating period

dcalmat Program EWBC: Average interval in days from date of calving to date of mating

dcalnm2 Program EWBC: Average date of calving for females conceived in the 2st oestrus in the mating period

dcalnm3 Program EWBC: Average date of calving for females conceived in the 3st oestrus in the mating period

dccf Program EWBC: Losses of castrates in the fattening period

dccf[i] Program EWDC: Losses of pure-bred ($i = 0$) and cross-bred ($i = 1$) castrates in the fattening period

dcd[i] Calves died to 48 hours expressed as proportion of calves born alive after dystocia in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

dcdi[i][j] Program EWDC: Incidence of claw diseases treated with antibiotics on day $j + 1$ ($j = 0, ..., DL - 1$) of lactation 1, 2 or 3 and subsequent

dce[i] Calves died to 48 hours expressed as proportion of calves born alive after easy calving in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

dconai Program EWBC: Average date of conception for cows conceived in the 1st oestrus in the mating period

dconnm2 Program EWBC: Average date of conception for cows conceived in the 2st oestrus in the mating period

dconnm3 Program EWBC: Average date of conception for cows conceived in the 3st oestrus in the mating period

dcostw[i] Program EWBC: Length of the winter period for which the costs are calculated for category i ($i = 1, ..., CC$ except categories $4, 14, 15$)

dcw Program EWBC: Losses of calves from 48 hours after calving to weaning (averaged over sexes and reproductive cycles)

dcw[i] Program EWDC: Losses of pure-bred ($i = 0$) and cross-bred ($i = 1$) calves from 48 hours after calving to the end of the rearing period (averaged over sexes and reproductive cycles)

DD Number of classes for calving performance

dd Program EWDC: Average days dry per cow

ddry[i] Daily dry matter intake[11] of category i ($i = 1, \ldots, CT$ in Program EWDC, $i = 1, \ldots, CC$ in Program EWBC). For calves (in EWDC, $i = 3, 8, 9, 10, CC+3, CC+8, CC+9, CC+10$), daily dry matter intake refers to the first feeding period only.

[11] In this and the following variables, "Daily dry matter intake" means "Actual daily dry matter intake" in EWDC and "Predicted daily dry matter intake" in EWDC.

ddry2[i] Program EWDC: Daily dry matter intake of calves of category i in the second feeding period ($i = 3, 8, 9, 10, CC+3, CC+8, CC+9, CC+10$)

ddry10 Program EWDC: Daily dry matter intake of breeding bulls in the third feeding period (category 10)

ddrybbs Program EWBC: Daily dry matter intake of breeding bulls in the herd in the summer feeding period

ddrybbw Program EWBC: Daily dry matter intake of breeding bulls in the herd in the winter feeding period

ddryfas[i] Program EWBC: Daily dry matter intake of category i of extensivelly fattened animals in the last feeding period after pasture

ddrys[i] Program EWBC: Daily dry matter intake of category i in the summer period ($i = 1, \ldots, CC$)

ddryt Program EWBC: Daily dry matter intake of breeding bulls in performance test (only for production system 1)

ddrytb Program EWBC: Daily dry matter intake of breeding bulls from weaning to the beginning of the performance test (only for production system 1)

ddryts Program EWBC: Daily dry matter intake of breeding bulls from the end of performance test till selling (only for production system 1)

ddryw[i] Program EWBC: Daily dry matter intake of category i in the winter period ($i = 1, \ldots, CC$)

ddrywf[i] Program EWDC: Daily dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves in the first feeding period

ddrywf2[i] Program EWDC: Daily dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves in the second feeding period

ddrywm[i] Program EWDC: Daily dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) male calves in the first feeding period

ddrywm2[i] Program EWDC: Daily dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) male calves in the second feeding period

dead48[i] Program EWBC: Probability that a calf born alive dies till 48 hours after calving in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

dead48f[i] Program EWBC: Probability that a female calf born alive dies till 48 hours after calving in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

dead48f[i][j] Program EWDC: Probability that a pure-bred ($i = 0$) or cross-bred ($i = 1$) female calf born alive dies till 48 hours after calving in reproductive cycle $j + 1$ ($j = 0, ..., LL - 1$)

dead48m[i] Program EWBC: Probability that a male calf born alive dies till 48 hours after calving in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

dead48m[i][j] Program EWDC: Probability that a pure-bred ($i = 0$) or cross-bred ($i = 1$) male calf born alive dies till 48 hours after calving in reproductive cycle $j + 1$ ($j = 0, ..., LL - 1$)

deadc[i] Program EWBC: Probability that a cow in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$) will bear a dead calf

deadfc[i] Program EWBC: Probability that a cow in reproductive cycle $i+1$ $(i = 0, ..., LL-1)$ will bear a dead female calf

deadfc[i][j] Program EWDC: Probability that a cow in reproductive cycle $j+1$ $(j = 0, ..., LL-1)$ will bear a dead pure-bred $(i = 0)$ or cross-bred $(i = 1)$ female calf

deadmc[i] Program EWBC: Probability that a cow in reproductive cycle $i+1$ $(i = 0, ..., LL-1)$ will bear a dead male calf

deadmc[i][j] Program EWDC: Probability that a cow in reproductive cycle $j+1$ $(j = 0, ..., LL-1)$ will bear a dead pure-bred $(i = 0)$ or cross-bred $(i = 1)$ male calf

deai Program EWBC: Date of ending the first part of the mating period covering the first possibility of a female to become pregnant (1st oestrus)

deltacow Program EWDC: In the calculation of economic weights: change in the number of cows

delta_d[i] Variable which indicates if the relative economic weight for the direct component of trait i is calculated ($delta\_d[i] = 1$) or not ($delta\_d[i] = 0$)

delta_m[i] Variable which indicates if the relative economic weight for the maternal component of trait i is calculated ($delta\_m[i] = 1$) or not ($delta\_m[i] = 0$)

deltamilk Program EWDC: In the calculation of economic weights: change in *milktot*

denm2 Program EWBC: Date of ending the 2nd part of the mating period covering the second possibility of females to become pregnant (2nd oestrus)

denm3 Program EWBC: Date of ending the 3rd part of the mating period (end of the mating period) covering the 3rd possibility of females to become pregnant (3rd oestrus)

depas Program EWBC: Date of ending pasture

dfcf Program EWBC: Losses of heifers in the fattening period

dfcf[i] Program EWDC: Losses of pure-bred $(i = 0)$ and cross-bred $(i = 1)$ heifers in the fattening period

dfrp Program EWBC: Losses of heifers in the rearing period (from weaning to mating)

dgcxas Program EWBC: Daily gain of castrates in the fattening period after extensive fattening on pasture

dgcxs Program EWBC: Daily gain of castrates in the summer period on pasture in extensive fattening

dgcxw Program EWBC: Daily gain of castrates in the winter period after their weaning in extensive fattening

dgfxas Program EWBC: Daily gain of heifers in the fattening period after extensive fattening on pasture

dgfxs Program EWBC: Daily gain of heifers in the summer period on pasture in extensive fattening

dgfxw Program EWBC: Daily gain of heifers in the winter period after their weaning in extensive fattening

discd[i] Program EWDC: Discarded milk due to claw disease per cow of category i ($i = NCP, ..., CC$)

discow[i] Program EWDC: Discarded milk due to clinical mastitis per cow of category i ($i = NCP, ..., CC$)

dismcd Program EWDC: Total discarded milk due to claw disease per cow and year

dismilk Program EWDC: Total discarded milk due to clinical mastitis per cow and year

DL Program EWDC: Parameter: maximal number of days in lactation ($DL = 400$)

dl[i] Program EWDC: Length of the lactation for cow of category i

dm Program EWBC: Days from purchase to reaching mature weight for breeding bulls

dmatpas Program EWBC: Average interval in days from average date of mating to the end of the summer season

dmcf Program EWBC: Losses of bulls in the intensive fattening period

dmcf[i] Program EWDC: Losses of pure-bred ($i = 0$) or cross-bred ($i = 1$) bulls in the fattening period

dmi[i][j] Program EWDC: Incidence of clinical mastitis on day j+1 ($j = 0, ..., DL-$ 1) of lactations 1, 2 or 3 and higher

dmilksum[i] Program EWDC: Change in milk production per cow of category i per reproductive cycle (used for the calculation of the economic weight for milk production), $i = NCP, ...CC$

dot Total governmental subsidy in the integrated production system per cow and year

dotcalf Program EWBC: Governmental subsidies per weaned calf

dotcowh Governmental subsidies per performance-tested cow and year

dotcowo Additional governmental subsidies per cow and year

dotcows Program EWBC: Governmental subsidies per slaughter cow

dotexpm Program EWBC: Governmental subsidies per exported male calf

dotfati Governmental subsidies per intensively fattened animal

dotfatx Program EWBC: Governmental subsidies per extensively fattened animal

dotmilk Program EWDC: Governmental subsidies per kg milk

dottest Program EWBC: Governmental subsidies per bull on performance test and per day. Program EWDC: Governmental support for rearing per breeding bull per day

dp[i] Program EWDC: Days in pregnancy for category i ($i = 22, 24, 25, ..., CC-4$)

dpascal Program EWBC: Average interval in days from the end of the summer season to calving

dpasmat Program EWBC: Average interval in days from the end of the summer season to the next mating period

dprfrep Program EWBC: Days of pregnancy of a purchased female for replacement

dresb Program EWBC: Dressing proportion of bulls

dresb[i] Program EWDC: Dressing proportion of pure-bred ($i = 0$) or cross-bred ($i = 1$) bulls

dresc Program EWBC: Dressing proportion of castrates

dresc[i] Program EWDC: Dressing proportion of pure-bred ($i = 0$) or cross-bred ($i = 1$) castrates

drescw Dressing proportion of cows

dresh Program EWBC: Dressing proportion of heifers

dresh[i] Program EWDC: Dressing proportion of pure-bred ($i = 0$) and cross-bred ($i = 1$) heifers

dryf[i] Dry matter per kg feed ration for intensively fattened animals of category i (Program EWBC: i = 4-6 and 12-17, Program EWDC: $i = 1, ..., CT$)

dryf10 Program EWDC: Dry matter per kg feed ration for breeding bulls from the end of the rearing period of calves till selling

dryf2[i] Program EWDC: Dry matter per kg feed ration for calves of category i ($i = 3, 8, 9, 10, CC+3, CC+8, CC+9, CC+10$) in the second feeding period within the rearing period

dryfwf[i] Program EWDC: Dry matter per kg feed ration for reared female calves in the first feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

dryfwf2[i] Program EWDC: Dry matter per kg feed ration for reared female calves in the second feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

dryfwm[i] Program EWDC: Dry matter per kg feed ration for reared male calves in the first feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

dryfwm2[i] Program EWDC: Dry matter per kg feed ration for reared male calves in the second feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

dryfx[i] Program EWBC: Dry matter per kg feed ration for fattening animals of category i ($i = 5, 6, 12, 13, 16, 17$) after extensive fattening on pasture

dryhayha Program EWBC: Amount of dry matter per ha of pasture land (without losses caused by grazing animals)

drys[i] Program EWBC: Dry matter per kg summer feed ration for animals of category i ($i = 1, ..., CC$ except $4, 14, 15$)

dryt Program EWBC: Dry matter per kg feed ration of breeding bulls in the performance test

drytb Program EWBC: Dry matter content per kg winter feed ration of breeding bulls before the performance test

drytse Program EWBC: Dry matter per kg feed ration of breeding bulls after the performance test

dryw[i] Program EWBC: Dry matter per kg winter feed ration for animals of category i ($i = 1, ..., CC$ except $4, 14, 15$)

ds[i] Program EWBC: Length (in days) of the summer period for category i ($i = 3, 8, 9, 25, ..., CC$)

ds0[i] Program EWBC: Length (in days) of the "zeroth" summer feeding period[12] after weaning for category i

ds1[i] Program EWBC: Length (in days) of the 1st summer feeding period after weaning for category i

ds2[i] Program EWBC: Length (in days) of the 2nd summer feeding period after weaning for category i

ds3[i] Program EWBC: Length (in days) of the 3rd summer feeding period after weaning for category i

dsd[i] Program EWBC: Days dry in the summer period for cow category i ($i = 25, ..., CC$)

dsl[i] Program EWBC: Days of lactation in the summer period for cow category i ($i = 25, ..., CC$) and available for calves of category i ($i = 3, 8, 9$)

dslg Program EWBC: Days from reaching mature weight to culling of breeding bulls

dsmp Program EWBC: Date of starting the mating period

dsnm2 Program EWBC: Date of starting the second part of mating period (start of 2nd oestrus within the mating period)

dsnm3 Program EWBC: Date of starting the third part of mating period (start of 3rd oestrus within the mating period)

dsp[i] Program EWBC: Days of pregnancy in the summer period for category i ($i = 22, CC + 9$)

dst Program EWBC: Days from weaning to the start of the performance test for bulls

[12] This period occurs only if calves are weaned before the end of the pasture period.

dsx Program EWBC: Days of the pasture summer period in extensive feeding of heifers or castrates

dt Program EWBC: Duration (in days) of the performance test for bulls

dtse Program EWBC: Days from the end of the performance test to selling bulls

dung[i] Amount of dung produced per animal of category i ($i = 1, ...CT$) per day

dung10 Program EWDC: Amount of dung per breeding bull per day

dungbb Program EWBC: Amount of dung per breeding bull in the herd during the winter housing period and per day

dungfi Program EWBC: Amount of dung per animal in intensive fattening and per day

dungfx Program EWBC: Amount of dung per animal in extensive fattening during the winter housing period and per day

dungwf[i] Program EWDC: Amount of dung produced per female calf and per day in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

dungwm[i] Program EWDC: Amount of dung produced per male calf and per day in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

dw[i] Program EWBC: Length (in days) of the winter period for category i ($i = 3, 8, 9, 18$)

dw0 Program EWBC: Date of weaning calves

dw1[i] Program EWBC: Length (in days) of the 1st winter feeding period after weaning for category i

dw2[i] Program EWBC: Length (in days) of the 2nd winter feeding period after weaning for category i

dw3[i] Program EWBC: Length (in days) of the 3rd winter feeding period after weaning for category i

dw4 Program EWBC: Length (in days) of the 4th winter feeding period after weaning for category $CC + 6$

dwd[i] Program EWBC: Days dry in the winter period for cow category i ($i = 25, ..., CC$)

dwl[i] Program EWBC: Days of lactation in the winter period for category i ($i = 25, ..., CC$)

dwp1[i] Program EWBC: Days of pregnancy in the first winter season for category i ($i = 1, \ldots, GG$)

dwp2[i] Program EWBC: Days of pregnancy in the second winter season for category i ($i = 1, \ldots, GG$)

dwx Program EWBC: Days in the winter period in extensive fattening of heifers or castrates

dys[i] Program EWBC: Vector of probabilities of dystocia occurrence in reproductive cycle $i+1$ ($i = 0, ..., LL-1$)

dys[i][j] Program EWDC: Vector of probabilities of dystocia occurrence per pure-bred ($i = 0$) or cross-bred ($i = 1$) calving in reproductive cycle $j+1$ ($j = 0, ..., LL-1$)

dysav Program EWBC: Average probability of dystocia per calving in the herd of the given structure

dysav[i] Program EWDC: Average probability of dystocia per pure-bred ($i = 0$) and cross-bred ($i = 1$) calving in the herd of the given structure

dysavave Program EWDC: Average dystocia incidence (calving scores $\geq$ *dyscl*) in the herd per calving

dysavh[i] Program EWDC: Average incidence of calving score i+1 ($i = 0, ..., DD-1$) per calving in the herd

dysavs[i][j][k] Program EWDC: Incidence of calving score $i+1$ ($i = 0, ..., DD-1$) per pure-bred ($j = 0$) or cross-bred ($j = 1$) calving in reproductive cycle $k+1$ ($k = 0, ...LL-1$) averaged over sexes

dysc[i] Program EWDC: Average dystocia incidence (calving scores $\geq$ *dyscl*) per calving in reproductive cycle $i+1$ ($i = 0, ...LL-1$)

dyscl Lowest calving score which is considered to be dystocia

dysf[i] Program EWBC: Vector of probabilities of dystocia occurrence when female is born in reproductive cycle $i+1$ ($i = 0, ..., LL-1$)

dysf[i][j] Program EWDC: Vector of probabilities of dystocia occurrence when pure-bred ($i = 0$) or cross-bred ($i = 1$) female is born in reproductive cycle $j+1$ ($j = 0, ..., LL-1$)

dysff[j][i] Program EWBC: Vector of probabilities of calving score $j+1$ ($j = 0, ..., DD-1$) when female is born in reproductive cycle $i+1$ ($i = 0, ..., LL-1$)

dysff[j][k][i] Program EWDC: Vector of probabilities of calving score $j+1$ ($j = 0, ..., DD-1$) when pure-bred ($k = 0$) or cross-bred ($k = 1$) female is born in reproductive cycle $i+1$ ($i = 0, ..., LL-1$)

dysff0[j][i] Original values of $dysff[j][i]$ (Must be stored during the calculation of economic weights.)

dysffl[j] Needed for the calculation of economic weights

dysffld[j] Needed for the calculation of economic weights

dysffldl[j] Needed for the calculation of economic weights

dysffldr[j] Needed for the calculation of economic weights

dysffll[j] Needed for the calculation of economic weights

dysfflmc Program EWBC: Mean score for calving performance for female calves

dysfflmc[j] Program EWDC: Mean score for calving performance for pure-bred ($j = 0$) or cross-bred ($j = 1$) female calves

dysfflql[j] Needed for the calculation of economic weights

dysfflqm[j] Needed for the calculation of economic weights

dysfflqr[j] Needed for the calculation of economic weights

dysfflr[j] Needed for the calculation of economic weights

dysm[i] Program EWBC: Vector of probabilities of dystocia occurrence when male is born in reproductive cycle $i+1$ ($i = 0, ..., LL-1$)

dysm[i][j] Program EWDC: Vector of probabilities of dystocia occurrence when pure-bred ($i = 0$) or cross-bred ($i = 1$) male is born in reproductive cycle $j+1$ ($j = 0, ..., LL-1$)

dysmat[i] Vector of probabilities that cows having dystocia in reproductive cycle $i+1$ ($i = 0, ..., LL-1$) will be mated in the following mating period

dysmm[j][i] Program EWBC: Vector of probabilities of calving score $j+1$ ($j = 0, ..., DD-1$) when male is born in reproductive cycle $i+1$ ($i = 0, ..., LL-1$)

dysmm[j][k][i] Program EWDC: Vector of probabilities of calving score $j+1$ ($j = 0, ..., DD-1$) when pure-bred ($k = 0$) or cross-bred ($k = 1$) male is born in reproductive cycle $i+1$ ($i = 0, ..., LL-1$)

dysmm0[j][i] Program EWBC: Needed for the calculation of the economic weight for calving performance

dysmm0[j][k][i] Program EWDC: Needed for the calculation of the economic weight for calving performance

dysmml[j] Program EWBC: Needed for the calculation of the economic weight for calving performance

dysmml[j][k] Program EWDC: Needed for the calculation of the economic weight for calving performance

dysmmld[j] Program EWBC: Needed for the calculation of the economic weight for calving performance

dysmmld[j][k] Program EWDC: Needed for the calculation of the economic weight for calving performance

dysmmldl[j] Program EWBC: Needed for the calculation of the economic weight for calving performance

dysmmldl[j][k] Program EWDC: Needed for the calculation of the economic weight for calving performance

dysmmldr[j] Program EWBC: Needed for the calculation of the economic weight for calving performance

dysmmldr[j][k] Program EWDC: Needed for the calculation of the economic weight for calving performance

dysmmll[j] Program EWBC: Needed for the calculation of the economic weight for calving performance

dysmmll[j][k] Program EWDC: Needed for the calculation of the economic weight for calving performance

dysmmlmc Program EWBC: Mean score for calving performance for male calves

dysmmlmc[j] Program EWDC: Mean score for calving performance for pure-bred ($j = 0$) or cross-bred ($j = 1$) male calves

dysmmlql[j] Program EWBC: Needed for the calculation of the economic weight for calving performance

dysmmlql[j][k] Program EWDC: Needed for the calculation of the economic weight for calving performance

dysmmlqm[j] Program EWBC: Needed for the calculation of the economic weight for calving performance

dysmmlqm[j][k] Program EWDC: Needed for the calculation of the economic weight for calving performance

dysmmlqr[j] Program EWBC: Needed for the calculation of the economic weight for calving performance

dysmmlqr[j][k] Program EWDC: Needed for the calculation of the economic weight for calving performance

dysmmlr[j] Program EWBC: Needed for the calculation of the economic weight for calving performance

dysmmlr[j][k] Program EWDC: Needed for the calculation of the economic weight for calving performance

dysscore[j] Program EWBC: Occurrence of calving score $j + 1$ per calving ($j = 0, ..., DD - 1$)

dysscoreav Program EWBC: Average calving score in the herd

dysscoreav[i] Program EWDC: Average calving score in the herd for pure-bred ($i = 0$) or cross-bred ($i = 1$) calving

dysscoreavf[i] Program EWDC: Average calving score in the herd for pure-bred ($i = 0$) or cross-bred ($i = 1$) calving when a female calf is born

dysscoreavm[i] Program EWDC: Average calving score in the herd for pure-bred ($i = 0$) or cross-bred ($i = 1$) calving when a male calf is born

ecm Program EWDC: Energy and protein requirement per kg milk with given fat and protein content

ecr2nmc Program EWBC: Conception rate of cows in the 2nd oestrus during the second part of the mating period for cows not having dystocia in reproductive cycles 1 to $LL - 1$ expressed as proportion of cows not being pregnant after the 1st oestrus

ecr3nmc Program EWBC: Conception rate of cows in the 3rd oestrus during the third part of the mating period for cows not having dystocia in reproductive cycles 1 to $LL - 1$ expressed as proportion of cows not being pregnant after the 2nd oestrus

ecrinc Program EWBC: Conception rate of cows in the 1st oestrus during the first part of the mating period for cows not having dystocia in reproductive cycles 1 to $LL-1$ expressed as proportion of cows mated in this oestrus

ecrinc[i] Program EWDC: Conception rate after insemination i+1 ($i = 0, ..., inmax-1$) for cows not having dystocia in reproductive cycles 1 to LL

edf[i] Net energy per kg dry matter of feed ration for animals of category i (Program EWBC: i = 4-6 and 12-17, Program EWDC: $i = 1, ..., CT$)

edf10 Program EWDC: Net energy content per kg dry matter of feed ration for breeding bulls from the end of the rearing period of calves till selling

edf2[i] Program EWDC: Net energy per kg dry matter of feed ration for calves of category i ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9, CC + 10$) in the second feeding period within the rearing period

edfwf[i] Program EWDC: Net energy per kg dry matter of feed ration for female calves in the first feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

edfwf2[i] Program EWDC: Net energy per kg dry matter of feed ration for female calves in the second feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

edfwm[i] Program EWDC: Net energy per kg dry matter of feed ration for male calves in the first feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

edfwm2[i] Program EWDC: Net energy per kg dry matter of feed ration for male calves in the second feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

edfx[i] Program EWBC: Net energy per kg dry matter of feed ration for fattened animals of category i ($i = 12, 17$) after extensive fattening on pasture

eds[i] Program EWBC: Net energy per kg dry matter of summer feed ration for animals of category i ($i = 1, ..., CC$ except $4, 14, 15$)

edt Program EWBC: Net energy per kg dry matter of feed ration for breeding bulls in the performance test

edtb Program EWBC: Net energy per kg dry matter of feed ration for breeding bulls before the performance test

edtse Program EWBC: Net energy per kg dry matter of feed ration for breeding bulls after the performance test

edw[i] Program EWBC: Net energy per kg dry matter of winter feed ration for animals of category i ($i = 1, ..., CC$ except $4, 14, 15$)

ew[i] Program EWBC: Economic value for trait i ($i = 1, ..., 29$) calculated for a change in the trait of $\pm 0.5\%$ (for numbering of traits see Section A.2 on page 127)

ew[i][j] Program EWDC: Economic values for trait i calculated for a change in the trait of $\pm 0.5\%$ ($i = 1, \ldots, 5,\ 9, \ldots, 25,\ 29, \ldots, 39$, for numbering of traits see Section A.2 on page 127) in progeny group j (pure-bred dairy progeny: $j = 0$, cross-bred beef x dairy progeny: $j = 1$, cross-bred progeny of cows in System 3: $j = 2$) expressed per dairy cow in Production System 4 (for $j = 0$ and $j = 1$) or per cross-bred cow in System 3 (for $j = 2$)

ew0[i] Program EWBC: Economic value for trait i ($i = 1, ..., 29$) calculated for a change in the trait of $\pm 1\%$

ew0[i][j] Program EWDC: Economic value for trait i ($i = 1, \ldots, 5,\ 9, \ldots, 25,\ 29, \ldots, 39$) calculated for a change in the trait of $\pm 1\%$

ewc[i][j] Program EWDC: Economic values for trait i in pure-bred dairy progeny expressed per pure-bred dairy calving (per cow calved after mating with dairy bulls, $j = 0$) or in cross-bred progeny expressed per cross-bred calving (per cow calved after mating with beef bulls, $j = 1$)

ew_d[i] Economic weight for direct traits i (Program EWBC: $i = 1, ..., 29$, Program EWDC: $i = 1, \ldots, 5,\ 9, \ldots, 25,\ 29, \ldots, 39$)

ewdiff[i] Program EWBC: Difference in economic values for trait i ($i = 1, ..., 29$) expressed in per cent: $ewdiff[i] = 100 \times (ew0[i] - ew[i])/ew[i]$

ewdiff[i][j] Program EWDC: Difference in economic values for trait i ($i = 1, \ldots, 5,\ 9, \ldots, 25,\ 29, \ldots, 39$) and progeny group j ($j = 0, 1$), for detail see variable $ew[i][j]$) expressed in per cent: $ewdiff[i][j] = 100 \times (ew0[i][j] - ew[i][j])/ew[i][j]$

ew_m[i] Economic weight for maternal traits (Program EWBC: $i = 1, ..., 29$, Program EWDC: $i = 1, \ldots, 5,\ 9, \ldots, 25,\ 29, \ldots, 39$))

ewopt Program EWDC: Option for the calculation of economic values (see Section 4.1.3)

ewr_da[i] Standardised economic weight for the direct component of trait i expressed as percentage of the sum of all standardised economic weights for both the direct and the maternal components (see equation 2.70)

ewr_dd[i] Standardised economic weight for the direct component of trait i expressed as percentage of the sum of all standardised economic weights for the direct components (see equation 2.68) or relative marginal economic value (see equation 2.50)

ewr_ma[i] Standardised economic weight for the maternal component of trait i expressed as percentage of the sum of all standardised economic weights for both the direct and the maternal components (see equation 2.71)

ewr_mm[i] Standardised economic weight for the maternal component of trait i expressed as percentage of the sum of all standardised economic weights for the maternal components (see equation 2.69)

ewst_d[i] Standardised economic weight for the direct component of trait i (see equation 2.65) or standardised marginal economic value of trait i (see equation 2.48)

ewst_m[i] Standardised economic weight for the maternal component of trait i (see equation 2.65)

ewsum Sum of the absolute values of the standardised economic weights for both the direct and the maternal trait components ($ewsum\_d + ewsum\_m$) or sum of the standardised marginal economic values of traits

ewsum_d Sum of the absolute values of the standardised economic weights for the direct trait components (see equation 2.66)

ewsum_m Sum of the absolute values of the standardised economic weights for the maternal trait components (see equation 2.66)

ewwd[i][j] Program EWDC: Temporary variable needed for the calculation of economic values of direct effects

ewwm[i][j] Program EWDC: Temporary variable needed for the calculation of economic values of maternal effects

exfc Program EWBC: Female calves sold expressed as proportion of surplus female calves. Program EWDC: cross-bred female calves sold expressed as proportion of surplus cross-bred female calves

exmc Program EWBC: Male calves sold expressed as proportion of male weaned calves

f[i] Program EWBC: Fresh feed requirement per animal in intensive fattening for category i ($i = 4-6, 12-17$). Program EWDC: Fresh feed requirement per animal of category i ($i = 1, ..., CT$)

f10 Program EWDC: Fresh feed requirement per animal of category 10 from the end of the rearing period of calves till selling

f2[i] Program EWDC: Fresh feed requirement per calf of category i ($i = 3, 8, 9, 10, CC+3, CC+8, CC+9, CC+10$) in the second feeding period within the rearing period

fas[i] Program EWBC: Winter fresh feed requirement per animal of category i ($i = 5, 6, 12, 13, 16, 17$) for extensively fattened animals after pasture

fase[i] Program EWBC: Winter fresh feed requirement per animal of category i ($i = 5, 6, 12, 13, 16, 17$) for extensively fattened animals after pasture calculated on the basis of the energy requirement

faspdi[i] Program EWBC: Winter fresh feed requirement per animal of category i ($i = 5, 6, 12, 13, 16, 17$) for extensively fattened animals after pasture calculated on the basis of the protein requirement

fat Fat content in milk

fat305ave Program EWDC: 305d fat yield (kg)

fatkg Program EWDC: Fat yield (kg) produced over the whole lactation

fbbs Program EWBC: Fresh feed requirement in the summer period per breeding bull from purchase to culling

fbbse Program EWBC: Fresh feed requirement in the summer period calculated on the basis of the energy requirement per breeding bull from purchase to culling

fbbspdi Program EWBC: Fresh feed requirement in the summer period calculated on the basis of the protein requirement per breeding bull from purchase to culling

fbbw Program EWBC: Fresh feed requirement in the winter period per bull from purchase to culling

fbbwe Program EWBC: Fresh feed requirement in the winter period calculated on the basis of the energy requirement per breeding bull from purchase to culling

fbbwpdi Program EWBC: Fresh feed requirement the in winter period calculated on the basis of the protein requirement per breeding bull from purchase to culling

fe[i] Program EWBC: Fresh feed requirement per animal of category i ($i = 4, 5, 6, 12, 13, 14, 15, 16, 17$) in intensive fattening calculated on the basis of the energy requirement. Program EWDC: Fresh feed requirement per animal of category i ($i = 1, ..., CT$) calculated on the basis of the energy requirement

fe10 Program EWDC: Fresh feed requirement calculated on the basis of the energy requirement per animal of category 10 from the end of the rearing period of calves till selling

fe2[i] Program EWDC: Fresh feed requirement per calf of category i ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9, CC + 10$) in the second feeding period within the rearing period calculated on the basis of the net energy requirement

feedcost Way of calculating the feeding cost (see Section 4.1.1.11 on page 58)

feedlot Program EWBC: Type of fattening (1-intensive, 2-extensive)

fewf[i] Program EWDC: Fresh feed requirement per female calf in the first feeding period within the rearing period calculated on the basis of the net energy requirement ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fewf2[i] Program EWDC: Fresh feed requirement per female calf in the second feeding period within the rearing period calculated on the basis of the net energy requirement ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fewm[i] Program EWDC: Fresh feed requirement per male calf in the first feeding period within the rearing period calculated on the basis of the net energy requirement ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fewm2[i] Program EWDC: Fresh feed requirement per male calf in the second feeding period calculated on the basis of the net energy requirement ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fix[i] Program EWDC: Fixed cost per day and animal of category i ($i = 1, ..., CT$)

fix10 Program EWDC: Fixed cost per breeding bull per day

fixwf[i] Program EWDC: Fixed cost per day per female reared calf ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fixwm[i] Program EWDC: Fixed cost per day per male reared calf ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fixcbb Program EWBC: Fixed cost per breeding bull in the herd per day

fixcbbt Program EWBC: Total fixed cost per breeding bull from purchase to culling

fixcbt Program EWBC: Fixed cost per breeding bull in performance test, per day

Table A.1: Possible values of the variable $flag[i]$. The values of the variable correspond to the numbers of the trait definitions as given in Appendix A.2.

Value of i	Possible values of $flag[i]$ in EWDC	Possible values of $flag[i]$ in EWBC
1	32, 33	6, 26
2	34, 35	7, 27
3	11, 29	8, 28
4	6, 26	11, 29
5	7, 27	
6	8, 28	
7	12, 40	
8	13, 41	

fixcc Program EWBC: Fixed cost per cow and day (including calf to weaning)

fixcfi Program EWBC: Fixed cost per animal and day in intensive fattening

fixcfx Program EWBC: Fixed cost per animal and day in extensive fattening

fixcrh Program EWBC: Fixed cost per replacement heifer and day, from weaning to calving

flag[i] Chooses always between two trait definitions in the calculation of relative economic weights (see Table A.1).

fpdi[i] Program EWBC: Fresh feed requirement per animal of category i ($i = 4-6, 12-17$) in intensive fattening calculated on the basis of the protein requirement. Program EWDC: Fresh feed requirement per animal of category i ($i = 1, ..., CT$) calculated on the basis of the protein requirement

fpdi10 Program EWDC: Fresh feed requirement calculated on the basis of the protein requirement per animal of category 10 from the end of the rearing period of calves till selling

fpdi2[i] Program EWDC: Fresh feed requirement per calf of category i ($i = 3, 8, 9, 10, CC+3, CC+8, CC+9, CC+10$) in the second feeding period within the rearing period calculated on the basis of the protein requirement

fpdiwf[i] Program EWDC: Fresh feed requirement per female calf in the first feeding period within the rearing period calculated on the basis of the protein requirement ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fpdiwf2[i] Program EWDC: Fresh feed requirement per female calf in the second feeding period within the rearing period calculated on the basis of the protein requirement ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fpdiwm[i] Program EWDC: Fresh feed requirement per male calf in the first feeding period within the rearing period calculated on the basis of the protein requirement ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fpdiwm2[i] Program EWDC: Fresh feed requirement per male calf in the second feeding period within the rearing period calculated on the basis of the

protein requirement ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fs[i] Program EWBC: Fresh feed requirement in the summer period per animal of category i ($i = 1, ..., CC$ except $4, 14, 15$)

fse[i] Program EWBC: Fresh feed requirement in the summer period calculated on the basis of the energy requirement per animal of category i ($i = 1, ..., CC$ except $4, 14, 15$)

fspdi[i] Program EWBC: Fresh feed requirement in the summer period calculated on the basis of the protein requirement per animal of category i ($i = 1, ..., CC$ except $4, 14, 15$)

ft Program EWBC: Fresh feed requirement per bull in the performance test

ftb Program EWBC: Fresh feed requirement per bull from weaning to the begin of the performance test

ftbe Program EWBC: Fresh feed requirement calculated on the basis of the energy requirement per bull from weaning to the begin of the performance test

ftbpdi Program EWBC: Fresh feed requirement in the summer period calculated on the basis of the protein requirement per bull from weaning to the begin of the performance test

fte Program EWBC: Fresh feed requirement calculated on the basis of the energy requirement per bull in the performance test

ftpdi Program EWBC: Fresh feed requirement in the summer period calculated on the basis of the protein requirement per bull in the performance test

fts Program EWBC: Fresh feed requirement per bull from the end of the performance test to selling

ftse Program EWBC: Fresh feed requirement per bull from the end of the performance test to selling calculated on the basis of the energy requirement

ftsepdi Program EWBC: Fresh feed requirement per bull from the end of the performance test to selling calculated on the basis of the protein requirement

fw0[i] Program EWBC: Fresh feed requirement in the winter period per animal of category i ($i = 1, ..., CC$ except $4, 14, 15$)

fwe[i] Program EWBC: Fresh feed requirement in the winter period calculated on the basis of the energy requirement per animal of category i ($i = 1, ..., CC$ except $4, 14, 15$)

fwf[i] Program EWDC: Fresh feed requirement per female calf in the first feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fwf2[i] Program EWDC: Fresh feed requirement per female calf in the second feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fwm[i] Program EWDC: Fresh feed requirement per male calf in the first feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fwm2[i] Program EWDC: Fresh feed requirement per male calf in the second feeding period within the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

fwpdi[i] Program EWBC: Fresh feed requirement in the winter period calculated on the basis of the protein requirement per animal of category i ($i = 1, ..., CC$ except $4, 14, 15$)

G Program EWBC: Maximal number of categories of animals including subcategories + 1 (set to 153)

gene_flow Sex group for which gene flow is calculated (Program EWBC: 1-sires, 2-dams, Program EWDC: 1-dairy sires, 2-dairy dams, 3-beef sires)

GG Program EWBC: Number of categories of animals including subcategories of progeny, $GG = 6(LL - 1) + 4 + 24 + 10 = CC + 10$

gstd Indicator variable if the genetic standard deviations for the direct and maternal components of the traits are not known or are not intended to be used for the calculation of relative economic weights ($gstd = 1$) or are known and given both for the direct and maternal components of the traits in INPUT32.TXT ($gstd = 2$) or are known but not differentiated between direct and maternal components of the traits so that one value is given per trait in INPUT33.TXT ($gstd = 3$)

gstd_d[i] Genetic standard deviation for the direct component of trait i ($i = 1, \ldots, NT-1$) or genetic standard deviation of trait i ($i = 1, \ldots, NT-1$) if direct and maternal trait components are not differentiated

gstd_m[i] Genetic standard deviation for the maternal component of trait i ($i = 1, \ldots, NT - 1$)

h1mpf Program EWBC: Heifers culled after the 1st mating period after their weaning for failure to conceive expressed as proportion of heifers which entered the 1st mating period

h1mprp Program EWBC: Heifers staying in the herd to the 2nd mating period (not pregnant or not mated) expressed as proportion of heifers which entered the 1st mating period

h2mpf Program EWBC: Heifers culled after the 2nd mating period for failure to conceive expressed as proportion of heifers which entered the 1st mating period

h2mprp Program EWBC: Heifers staying in the herd to the 3rd mating period (not pregnant or not mated) expressed as proportion of heifers which entered the 1st mating period

h3mpf Program EWBC: Heifers culled after the 3rd mating period for failure to conceive expressed as proportion of heifers entered the 1st mating period

hcmat1 Program EWBC: Heifers culled for failure to conceive after their 1st mating period expressed as proportion of heifers not being pregnant in their 1st mating period

hcmat1p Program EWBC: Heifers culled after the 1st mating period for failure to conceive expressed as proportion of heifers culled after all mating periods for heifers (maximally 3 periods)

hcmat2 Program EWBC: Heifers culled for failure to conceive after their 2nd mating period expressed as proportion of heifers not being pregnant in their 2nd mating period

hcmat2p Program EWBC: Heifers culled for failure to conceive after their 2nd mating period expressed as proportion of heifers culled after all mating periods for heifers (maximally 3 periods)

hcmat3p Program EWBC: Heifers culled for failure to conceive after their 3rd mating period expressed as proportion of heifers culled after all mating periods for heifers (maximally 3 periods)

hcon1mat Program EWBC: Heifers pregnant in their 1st mating period after weaning expressed as proportion of heifers having 1st calving (from all pregnant heifers)

hcon2mat Program EWBC: Program EWBC: Heifers conceived in their 2nd mating period expressed as proportion of heifers having 1st calving

hcon3mat Program EWBC: Heifers conceived in their 3rd mating period expressed as proportion of heifers having 1st calving

hd[i] Vector of the numbers of expressions for direct traits ($i = 1, ..., acd + acs + 2$), see Section 2.8

herdbook Fraction of performance-tested cows

hm[i] Vector of the numbers of expressions for maternal traits ($i = 1, ..., acd + acs + 2$), see Section 2.8

hmpf Program EWBC: Heifers totally culled after the 1st, 2nd and 3rd mating periods expressed as proportion of heifers entered the 1st mating period. Program EWDC: Heifers culled because of no pregnancy after maximum number of inseminations

i Index variable

i1 Index variable

i2 Index variable

i3 Index variable

i4 Program EWDC: Upper limit for the number of categories ($i4 = C1$ for $cb = 0$ and $i4 = C$ for $cb = 1$)

inint Program EWDC: Interval between two subsequent inseminations

ind_a30 Program EWDC: Indicator variable, if data for curd firmness are available ($ind\_a30 = 1$) or not ($ind\_a30 = 0$)

ind_RCT Program EWDC: Indicator variable, if data for rennet coagulation time are available ($ind\_RCT = 1$) or not ($ind\_RCT = 0$)

inmax Program EWDC: Maximal number of inseminations per cow after calving

inmaxh	Program EWDC: Maximal number of inseminations per heifer
INS	Program EWDC: Maximal number of inseminations (set to 8)
insc	Program EWBC: Mating type for cows (1: AI is applied at least in the 1st oestrus in the mating period, 2: natural mating only)
insh	Program EWBC: Mating type for heifers (1: AI is applied at least in the 1st oestrus in the mating period, 2: natural mating only)
intcm	Average length of interval between calving and the beginning of the mating period
intcmc	Program EWBC: Average length of interval from calving to mating for cows (average from all reproductive cycles)
intconc[i]	Program EWDC: Interval between the 1st insemination and conception of cows in reproductive cycle $i+1$ ($i = 0, ...LL-2$)
intconh	Program EWDC: Interval between the 1st insemination and conception of heifers
ircdy[i]	Program EWDC: Vector of the total incidence rate of claw diseases (number of claw disease cases) per cow-year at risk in lactation $i+1$, $i = 1, \ldots, LL-1$ (in the whole calving interval)
ircmy[i]	Program EWDC: Incidence rate of clinical mastitis (number of clinical mastitis cases) per cow-year at risk in lactation $i+1$ ($i = 0, ..., LL-1$)
J	Program EWDC: Takes value 2
j	Index variable
j1	Index variable
ja	Temporary variable in Program EWDC
jb	Temporary variable in Program EWDC
jj	Index variable
k	Index variable
k2	Program EWBC: Coefficient connected with the lactation curve (for details see Section 2.3.1)
k3	Program EWBC: Coefficient connected with the lactation curve (for details see Section 2.3.1)
k4	Program EWBC: Coefficient connected with the lactation curve (for details see Section 2.3.1)
kbd	Program EWBC: Adjustment factor for breed energy requirement for maintenance for dry cows
kbl	Program EWBC: Adjustment factor for breed energy requirement for maintenance for lactating cows
kbwmf	Program EWBC: Ratio of birth weight of male calves to birth weight of female calves

kbwmf[i] Program EWDC: Ratio of birth weight of male calves to birth weight of female calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kce Program EWBC: Adjustment factor for energy requirement according to the maturity type of castrates in fattening (fixed value in the program according to the maturity type of progeny)

kce[i] Program EWDC: Adjustment factor for energy requirement according to the maturity type of castrates ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kcon2c Program EWBC: Ratio of conception rate in the 2nd oestrus to conception rate in the 1st oestrus of cows

kcon2h Program EWBC: Ratio of conception rate in the 2nd oestrus to conception rate in the 1st oestrus of heifers

kcon3c Program EWBC: Ratio of conception rate in the 3rd oestrus to conception rate in the 1st oestrus of cows

kcon3h Program EWBC: Ratio of conception rate in the 3rd oestrus to conception rate in the 1st oestrus of heifers

kconc[i] Program EWDC: Ratio of the conception rate of cows after insemination $i+1$ ($i = 0, ..., inmax - 1$) to conception rate after the 1st insemination

kconh[i] Program EWDC: Ratio of the conception rate of heifers after insemination $i + 1$ ($i = 0, ..., inmax - 1$) to conception rate after the 1st insemination

kcp Program EWBC: Adjustment factor for protein requirement according to the maturity type of castrates in fattening (fixed value in the program according to the maturity type of progeny)

kcp[i] Program EWDC: Adjustment factor for protein requirement according to the maturity type of castrates ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kdgfxwas Program EWBC: Ratio of average daily gain of heifers in extensive fattening after pasture to average daily gain of heifers in the winter period after weaning

kdgfxws Program EWBC: Ratio of average daily gain of heifers in extensive fattening in the pasture period to average daily gain of heifers in the winter period after weaning

kdgxascf Program EWBC: Ratio of average daily gain of castrates after pasture to average daily gain of heifers in the winter period after weaning, extensive fattening

kdgxscf Program EWBC: Ratio of average daily gain of castrates on pasture to average daily gain of heifers in the winter period after weaning, extensive fattening

kdgxwcf Program EWBC: Ratio of average daily gain of castrates in the winter period to average daily gain of heifers in the winter period after weaning, extensive fattening

kdresb Dressing proportion of bulls not reaching target slaughter weight as proportion of dressing proportion of bulls reaching target slaughter weight

kdresbh Program EWBC: Ratio of dressing proportion of bulls at slaughter to dressing proportion of heifers at slaughter

kdresbh[i] Program EWDC: Ratio of dressing proportion of bulls at slaughter to dressing proportion of heifers at slaughter ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kdresc Dressing proportion of castrates not reaching the target slaughter weight as proportion of dressing proportion of castrates reaching target slaughter weight

kdresch Program EWBC: Ratio of dressing proportion of castrates at slaughter to dressing proportion of heifers at slaughter

kdresch[i] Program EWDC: Ratio of dressing proportion of castrates at slaughter to dressing proportion of heifers at slaughter ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kdresh Dressing proportion of heifers not reaching the target slaughter weight as proportion of dressing proportion of heifers reaching target slaughter weight

kdrscwh Program EWBC: Ratio of dressing proportion of cows at slaughter to dressing proportion of heifers at slaughter

kff Adjustment factor for feed requirement according to feed losses in intensive fattening

kfpa Program EWBC: Adjustment factor for feed requirement according to feed losses for grazing animals

kfw Program EWBC: Adjustment factor for feed requirement according to feed losses for winter feeding in the pasture system. Program EWDC: Adjustment factor for feed requirement according to feed losses for indoor systems (cows, heifers and calves)

kg10 Program EWDC: Ratio of average daily gain of breeding bulls to average daily gain of heifers in fattening

kgaincf Program EWBC: Ratio of average daily gain of castrates in fattening to average daily gain of heifers in fattening

kgaincf[i] Program EWDC: Ratio of average daily gain of castrates in fattening to average daily gain of heifers in fattening ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kgainmf Program EWBC: Ratio of average daily gain of bulls in fattening to average daily gain of heifers in fattening

kgainmf[i] Program EWDC: Ratio of average daily gain of bulls in fattening to average daily gain of heifers in fattening ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kgcmf[i] Program EWDC: Ratio of average daily gain of male calves to average daily gain of female calves from birth to the end of the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kgcon1mf Program EWBC: Ratio of average daily gain of male calves to average daily gain of female calves from birth to the first control

kgcon2mf Program EWBC: Ratio of average daily gain of male calves to average daily gain of female calves from the first to the second control

kgcon3mf Program EWBC: Ratio of average daily gain of male calves to average daily gain of female calves from the second to the third control

kghccf[i] Program EWDC: Ratio of average daily gain of heifers from the 1st mating to calving to average daily gain of female calves in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kghcf[i] Program EWDC: Ratio of average daily gain of heifers from the end of the rearing period to the 1st mating to average daily gain of female calves in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

khe Program EWBC: Adjustment factor for energy requirement according to the maturity type of heifers in fattening (fixed value in the program according to the maturity type of progeny)

khp Program EWBC: Adjustment factor for protein requirement according to the maturity type of heifers in fattening (fixed value in the program according to the maturity type of progeny)

km Program EWBC: Coefficient connected with the lactation curve (for details see Section 2.3.1)

kmatc Program EWDC: Ratio of the weight of dairy heifers at the 1st mating to mature weight of dairy cows

kmcwhmin Program EWBC: Coefficient ($= whmin/mcw$)

kmwbc Program EWBC: Ratio of mature weight of bulls to mature weight of cows of the same breed

kp21 Program EWBC: Ratio of the probability that a live-born calf dies from calving to 48 hours after calving to the probability of still-born calves

kp21[i] Program EWDC: Ratio of the probability that a live-born dairy ($i = 0$) or cross-bred ($i = 1$) calf dies from calving to 48 hours after calving to the probability of still-born calves

kpm1 Program EWBC: Ratio of the probability of still-born male calves to the probability of still-born female calves

kpm1[i] Program EWDC: Ratio of the probability of still-born male calves to the probability of still-born female calves ($i = 0$: pure-bred calves, $i = 1$: cross-bred calves)

kpm2 Program EWBC: Ratio of the probability that a live-born male calf dies from calving to 48 hours after calving to the probability that a live-born female calf dies from calving to 48 hours after calving

kpm2[i] Program EWDC: Ratio of the probability that a live-born male calf dies from calving to 48 hours after calving to the probability that a live-born female calf dies from calving to 48 hours after calving ($i = 0$: pure-bred calves, $i = 1$: cross-bred calves)

kpr[i] Coefficient for price decrease for animals of category i ($i = 13, 15, 16$, and $21 + 6 \times r$ with $r = 1, ..., LL$ in programs EWBC and EWDC, and $i = CC + 13, CC + 15, CC + 16$ in Program EWDC only) involuntarily culled

kslb Program EWBC: Coefficient to calculate the optimal slaughter weight of intensively fattened bulls from the mature weight of cows (ratio of target slaughter weight of fattened bulls to mature weight of cows)

kslb[i] Program EWDC: Coefficient to calculate the optimal slaughter weight of intensively fattened bulls from the mature weight of cows (ratio of target slaughter weight of fattened bulls to mature weight of cows, $i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kslc Program EWBC: Coefficient to calculate the optimal slaughter weight of intensively fattened castrates from the mature weight of cows (ratio of target slaughter weight of fattened castrates to mature weight of cows)

kslc[i] Program EWDC: Coefficient to calculate the optimal slaughter weight of intensively fattened castrates from the mature weight of cows (ratio of target slaughter weight of fattened castrates to mature weight of cows, $i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kslcx Program EWBC: Coefficient to calculate the optimal slaughter weight of extensively fattened castrates from the mature weight of cows

kslh Program EWBC: Coefficient to calculate the optimal slaughter weight of intensively fattened heifers from the mature weight of cows (ratio of target slaughter weight of fattened heifers to mature weight of cows)

kslh[i] Program EWDC: Coefficient to calculate the optimal slaughter weight of intensively fattened heifers from the mature weight of cows (ratio of target slaughter weight of fattened heifers to mature weight of cows, $i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

kslhx Program EWBC: Coefficient to calculate the optimal slaughter weight of extensively fattened heifers from the mature weight of cows

kt Adjustment factor for energy requirement for maintenance according to technology (kt takes either the value of ktb or of ktf)

ktb Adjustment factor for energy requirement for maintenance according to technology - bind technology

ktf Adjustment factor for energy requirement for maintenance according to technology - free technology

ktp Adjustment factor for energy requirement for maintenance according to technology - pasture

L Maximal number of reproductive cycles (set to 20 in EWBC and to 15 in EWDC)

labherd Program EWDC: Herdsman's time dealing with an average clinical mastitis case (treatment, separate milking etc.)

labherdcd Program EWDC: Average herdman's (or trimmer) time dealing with an average claw disease case (both antibiotic treatment and treatment without antibiotics)

labvet — Program EWDC: Veterinarian's time spent per average clinical mastitis case

labvetcd — Program EWDC: Average veterianarian's time spent per antibiotic treatment of claw disease

l_inv — Length of the investment period (symbol T is used for this variable in Section 2.8)

l1[i] — Vector of relative frequencies of the individual categories of animals when the cow herd is in the stationary state. For $i = 25, ..., CC$, it holds $l1[i] = l2[i - 24]$ with $\sum_{i=25}^{CC} l1[i] = 1$. The remaining elements of the vector ($i = 1, ..., 24$ for all systems and $i = CC + 1, ..., CT$ for Program EWDC only) are the relative frequencies of the progeny (on a per year basis) which are derived from the frequencies of the cow categories. Assuming that a cow has one calf per year on average, the sum of all elements will be approximately 2.

l2[i] — Probability that in the stationary state of the whole production system, a cow belongs to category $i + 24$ ($i = 1, ..., TT$)

l2_0[i] — The same as before

L3 — Program EWDC: Number of reproductive cycles in System 3 (read from file FROM1_3.TXT - see Section 5.1.3 on page 120)

l3[i] — Cows calving in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$) expressed as proportion of cows entering any reproductive cycle ($\sum_{i=0}^{LL-1} l3[i] \leq 1$)

l4[i] — Program EWBC: Cows entering reproductive cycle $i+1$ ($i = 0, ..., LL-1$) expressed as proportion of cows entering any reproductive cycle ($\sum_{i=0}^{LL-1} l4[i] = 1$)

labdys[j] — Stock-man hours connected with calving difficulty score $j + 1$ ($j = 0, ..., DD - 1$)

lactcur — Program EWBC: Way of calculating the parameters for the lactation curve (1: parameters are known and are input parameters, 2: parameters are calculated in the program)

lengbt — Program EWBC: Length of the performance test for bulls

lghrcyc — Program EWBC: Length of the reproductive cycle (fixed to 365 days)

lgpre — Length of pregnancy

life[i] — Productive lifetime of a cow of category i ($i = 25, ..., CC$)

lifebb — Program EWBC: Productive lifetime of breeding bulls in numbers of reproductive cycles of cows

LL — Number of lactations (reproductive cycles)

lm2 — Program EWBC: Day of peak milk of two-years old cows (parameter LM_2 in Section 2.3.1)

lm3 — Program EWBC: Day of peak milk of three-years old cows (parameter LM_3 in Section 2.3.1)

lm4 — Program EWBC: Day of peak milk of four-years old cows (parameter LM_4 in Section 2.3.1)

lmm — Program EWBC: Day of peak milk of cows older than four years (parameter LM_m in Section 2.3.1)

losc — Average cow losses in the herd (sum of cows died and cows culled for health problems other than dystocia)

losff — Losses of feed in intensive fattening

losfpa — Program EWBC: Losses of feed on pasture

losfw — Program EWBC: Probability that a born female calf dies from 48 hours after birth to weaning

losfw[i] — Program EWDC: Probability that a born female calf dies from 48 hours after birth to the end of the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

loshin[i] — Program EWDC: Losses of heifers from the end of the rearing period to the 1st insemination ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

losmw — Program EWBC: Probability that a born male calf dies from 48 hours after birth to weaning

losmw[i] — Program EWDC: Probability that a born male calf dies from 48 hours after birth to the end of the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

lossmcd — Program EWDC: Losses for discarded milk due to claw disease per cow and year

lossmilk — Program EWDC: Losses for discarded milk due to clinical mastitis per cow and year

losstcd — Program EWDC: Total financial loss from claw disease per cow and year

losstotal — Program EWDC: Total financial loss from clinical mastitis per cow and year

loswf — Losses of feed in winter feeding (Program EWBC) or in indoor feeding of cows, calves and heifers (Program EWDC)

m_gf[i] — Vector of dimension $acs + acd + 2$ (in Program EWBC) or of dimension acm (in Program EWDC) used in the calculation of gene flow (see Section 2.8)

m_gf0[i] — Vector $\mathbf{m}_\mathbf{k}^{[\mathbf{t}]}$ of dimension $acs + acd + 2$ (in Program EWBC) or of dimension acm (in Program EWDC) used in the calculation of gene flow at the end of the investment period ($t = T$, see Section 2.8)

m_sum[i] — Vector $\sum_{t=1}^{T} \mathbf{m}_\mathbf{k}^{[\mathbf{t}]}(1+r)^{-t}$ of dimension $acs+acd+2$ (in Program EWBC) or of dimension acm (in Program EWDC) used in the calculation of gene flow (see Section 2.8). The vector contains the number of discounted expressions for the individual age-sex groups.

mast_inc — Program EWDC: Variable indicating if data from mastitis incidence are available ($mast\_inc = 1$) or not ($mast\_inc = 0$)

matcross — Program EWDC: Maturity type of cross-bred progeny (1-early, 2-middle, 3-late)

matpur Program EWDC: Maturity type of pure-bred progeny (1-early, 2-middle, 3-late)

maturity Program EWBC: Maturity type of progeny (1-early, 2-middle, 3-late)

mcw Program EWBC: Mature weight of cows (weight of cows after the 3rd calving)

mcwb Program EWDC: Mature weight of beef cows their sons are used for terminal crossing (weight of cows after the 3rd calving)

mcwd Program EWDC: Mature weight of dairy cows (weight of cows after the 3rd calving)

milk Program EWDC: Average milk yield per cow and year

milk21 Program EWDC: $milk21 = milk305[1]/milk305[0]$

milk31 Program EWDC: $milk31 = milk305[2]/milk305[0]$

milk305[i] Program EWDC: 305-d milk yield in lactation $i+1$ ($i = 0, ..., LL-1$)

milk305ave Program EWDC: 305-d milk yield averaged over lactations

milkprice Program EWDC: Option for the calculation of the milk price (see Section 4.1.1.15)

milkquota Program EWDC: Indicator variable for quota for milk market (0: no quota, 1: quota for milk yield only, 2: quota for milk yield and fat content)

milksum[i] Program EWDC: Milk production per cow of category i ($i = 25, ...CC$)

milktot Program EWDC: Total milk production in the herd

milktoth Program EWDC: In the calculation of economic weights: the value of *milktot* for the increased value of the given trait

milktotl Program EWDC: In the calculation of economic weights: the value of *milktot* for the decreased value of the given trait

milktotm Program EWDC: In the calculation of economic weights: keeps the value of *milktot*

min[i] Program EWBC: Mineral requirement per animal of category i ($i = 1, ..., CC$ except $4, 14, 15$) and per day

mo Program EWBC: Temporary variable (month - part of the date)

mp2 Program EWBC: Peak milk yield in kg per day for 2-year old cows (on pasture with suckling calf - parameter M_{p2} in Section 2.3.1)

mp3 Program EWBC: Peak milk yield in kg per day for 3-year old cows (on pasture with suckling calf - parameter M_{p3} in Section 2.3.1)

mp4 Program EWBC: Peak milk yield in kg per day for 4-year old cows (on pasture with suckling calf - parameter M_{p4} in Section 2.3.1)

mpm Program EWBC: 2.3.1)

mpm0 Program EWBC: Peak milk in kg per day (on pasture with suckling calf - parameter M_{pm0} in Section 2.3.1)

mSCS	Program EWDC: Mean of somatic cell score in the dairy cow population
msel	Program EWBC: Bulls selected expressed as proportion of performance-tested bulls
mtest	Program EWBC: Proportion of male weaned calves performance tested
mtest[i]	Program EWDC: Proportion of male calves alive at 48 hours after birth that are sold as breeding males (e.g. to test stations or AI stations, $i = 0$: pure-bred animals, $i = 1$: cross-bred animals)
mwb	Program EWBC: Mature weight of bulls
mxmc[i]	Program EWDC: Proportion of male calves alive at 48 hours after birth that are determined for selling outside of the evaluated production system within each progeny group i ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)
n	Number of cow categories
n_sac	Number of the sex-age class for which the gene flow will be calculated
n1	Temporary variable (number of variables in the input file)
n2	Temporary variable (number of the input file)
na30	Program EWDC: Number of thresholds for curd firmness in the milk pricing system
Ncal	Program EWBC: Number of calvings in the herd per cow and reproductive cycle
Ncal[i]	Program EWDC: Number of calvings in the herd per cow and reproductive cycle ($i = 0$: calvings after pure-bred mating, $i = 1$: calvings after cross-bred mating)
Ncalt	Program EWDC: Total number of calvings in the herd per cow and reproductive cycle ($Ncalt = Ncal[0] + Ncal[1]$)
nccf	Program EWBC: Number of fattened castrates slaughtered before reaching the required slaughter weight expressed as proportion of the total number of fattened castrates
nccf[i]	Program EWDC: Number of fattened castrates slaughtered before reaching the required slaughter weight expressed as proportion of the total number of fattened castrates ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)
ncows	Program EWBC: Number of slaughtered cows per cow and year
NCP	Program EWDC: Number of categories of pure-bred (or cross-bred) progeny + 1, fixed to 25.
ncp[i]	Program EWBC: Probability that a calved cow in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$) will be not pregnant after the maximal number of inseminations
nd[i]	Program EWDC: Ratio days dry to calving interval in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

ndaycc Program EWBC: Average number of days that a cow culled within the reproductive cycle for health problems excluding dystocia stayed in the herd from previous calving

ndaycc[i] Program EWDC: Average number of days that a cow culled within reproductive cycle $i+1$ ($i = 0, ..., LL-1$) for health problems excluding dystocia stayed in the herd from previous calving

ndaycd Program EWBC: Average number of days that a cow died within the reproductive cycle stayed in the herd from previous calving

ndaycd[i] Program EWDC: Average number of days that a cow died within reproductive cycle $i+1$ ($i = 0, ..., LL-1$) stayed in the herd from previous calving

ndaycw Program EWBC: Average number of days that a cow culled after calf weaning due to failure to conceive stayed in the herd from previous calving (assuming the cows are culled at the end of the summer season)

ndaydys Average number of days that the cow culled due to dystocia stayed in the herd from previous calving

NDEc[i] Number of discounted expressions for cost in category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$) per cow and reproductive cycle

NDEd Program EWBC: Number of discounted expressions for direct traits for the selection group (sires, dams), per cow summed over the investment period

NDEdys Number of discounted expressions for dystocia cost for the selection group (sires, dams), per cow summed over the investment period

NDEm Program EWBC: Number of discounted expressions for maternal traits for the selection group (sires, dams), per cow summed over the investment period

NDEr[i] Number of discounted expressions for revenues in category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: ($i = 1, ..., CT$), per cow and reproductive cycle

ne[i] Total net energy requirement per animal of category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

ne10 Program EWDC: Net energy requirement per animal of category 10 from the end of the rearing period of calves till selling

ne2[i] Program EWDC: Net energy requirement for a calf of category i ($i = 3, 8, 9, 10, CC+3, CC+8, CC+9, CC+10$) in the second feeding period within the rearing period of calves

neas[i] Program EWBC: Net energy requirement needed for reaching the required slaughter weight of extensively fattened animals of category i ($i = 12, 17$) after the summer fattening period on pasture

nebbm Program EWBC: Net energy requirement from purchase to reaching mature weight for breeding bulls

nebbs Program EWBC: Net energy requirement from purchase to slaughter for breeding bulls in the summer feeding period

nebbsl Program EWBC: Net energy requirement from reaching mature weight to slaughter for breeding bulls

nebbw Program EWBC: Net energy requirement from purchase to slaughter for breeding bulls in the winter feeding period

nebt Program EWBC: Net energy requirement from weaning to the start of the performance test for bulls

neg[i] Program EWDC: Net energy requirement for growth per cow of category i ($i = 25, ...CC$)

negs[i] Program EWBC: Net energy requirement per cow of category i ($i = 25, ..., CC$) for growth in the summer feeding period

negw[i] Program EWBC: Net energy requirement per cow of category i ($i = 25, ..., CC$) for growth in the winter feeding period

nel[i] Program EWDC: Net energy requirement for lactation per cow of category i ($i = 25, ..., CC$)

nem[i] Program EWDC: Net energy requirement for maintenance per cow of category i ($i = 25, ..., CC$)

nems[i] Program EWBC: Net energy requirement per cow of category i ($i = 25, ..., CC$) for maintenance in the summer feeding period

nemw[i] Program EWBC: Net energy requirement per cow of category i ($i = 25, ..., CC$) for maintenance in the winter feeding period

nepc[i] Total net energy requirement for pregnancy per animal of category i ($i = 22, 25, ..., CC$)

nes[i] Program EWBC: Net energy requirement per animal of category i ($i = 1, ..., CC + 10$ except $4, 14, 15$) in the summer feeding period

nes0[i] Program EWBC: Net energy requirement in the "zeroth" summer feeding period[13] after weaning per animal of category i ($i = CC+1, ..., CC+10$)

nes1[i] Program EWBC: Net energy requirement in the 1st summer feeding period after weaning per animal of category i

nes2[i] Program EWBC: Net energy requirement in the 2nd summer feeding period after weaning per animal of category i

nes3[i] Program EWBC: Net energy requirement in the 3rd summer feeding period after weaning per animal of category i

nescal[i] Program EWBC: Total net energy requirement in the summer feeding period per cow of category i ($i = 25, ..., CC$) that had calved in a reproductive cycle

nesl[i] Program EWBC: Net energy available per calf of category i ($i = 3, 8, 9$) in the summer feeding period from cows' milk ($i = 25, ..., CC$)

nesncal[i] Program EWBC: Total net energy requirement in the summer feeding period per cow of category i ($i = 25, ..., CC$) that had not calved at the entrance of a reproductive cycle

[13] This period occurs only if calves are weaned before the end of the pasture period.

nesp[i] Program EWBC: Net energy requirement for pregnancy in the summer feeding period per animal of category i ($i = 20, 22, 25-CC, CC+9, CC+10$)

net Program EWBC: Net energy requirement per bull in the performance test

netse Program EWBC: Net energy requirement per bull from the end of the performance test to selling (category 10)

new[i] Program EWBC: Net energy requirement per animal of category i ($i = 1, ..., CC + 10$ except $4, 14, 15$) in the winter feeding period

new1[i] Program EWBC: Net energy requirement in the 1st winter feeding period after weaning per animal of category i

new2[i] Program EWBC: Net energy requirement in the 2nd winter feeding period after weaning per animal of category i

new3[i] Program EWBC: Net energy requirement in the 3rd winter feeding period after weaning per animal of category i

new4 Program EWBC: Net energy requirement in the 4th winter feeding period after weaning for category $CC + 4$

newcal[i] Program EWBC: Total net energy requirement in the winter feeding per cow of category i ($i = 25, ..., CC$) that had calved in a reproductive cycle

newf[i] Program EWDC: Net energy requirement per female calf from birth to the end of the first feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

newf2[i] Program EWDC: Net energy requirement per female calf in the second feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

newl[i] Program EWBC: Net energy from cows' milk available per calf of category i ($i = 3, 8, 9$) in the the winter feeding period ($i = 25, ..., CC$)

newm[i] Program EWDC: Net energy requirement per male calf from birth to the end of the first feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

newm2[i] Program EWDC: Net energy requirement per male calf in the second feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

newncal[i] Program EWBC: Total net energy requirement in the winter feeding period per cow of category i ($i = 25, ..., CC$) that had not calved at the entrance of the reproductive cycle

newp[i] Program EWBC: Net energy requirement for pregnancy in the winter period per animal of category i ($i = 22, 25, ..., CC$)

nfat Program EWDC: Number of thresholds for milk fat content in the milk pricing system

Nfav Female calves available for fattening or selling as proportion of weaned or reared female calves

Nfc48a Program EWBC: Number of female calves staying alive 48 hours after calving per cow and reproductive cycle

Nfc48a[i] Program EWDC: Number of female calves staying alive 48 hours after calving per cow and reproductive cycle ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

Nfcba Program EWBC: Number of female calves born alive per cow and reproductive cycle

Nfcba[i] Program EWDC: Number of female calves born alive per cow and reproductive cycle ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

nfcf Program EWBC: Fattened heifers slaughtered before reaching the required slaughter weight expressed as proportion of the total number of fattened heifers

nfcf[i] Program EWDC: Fattened heifers slaughtered before reaching the required slaughter weight expressed as proportion of the total number of fattened heifers ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

Nfcw Program EWBC: Number of female calves weaned per cow and reproductive cycle

Nfcw[i] Program EWDC: Number of female calves reared per cow and reproductive cycle ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

Nffa Program EWBC: Heifers available for fattening per cow and reproductive cycle

Nffa[i] Program EWDC: Heifers available for fattening per cow and reproductive cycle ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

Nfmat Program EWBC: Number of heifers per cow and reproductive cycle that must enter the first mating period after weaning if no heifers are sold pregnant. Program EWDC: Number of pure-bred heifers per cow and reproductive cycle that must be firstly inseminated if no heifers are sold pregnant

Nfrer Program EWDC: Number of heifers that must be reared per cow and year for herd replacement if no breeding heifers are sold

Nfrp Program EWBC: Replacement heifers expressed as proportion of all born calves

nin[i] Program EWDC: Number of inseminations per female of category i ($i = 22, 24, 25, ...CC - 3$)

ninr[i] Program EWDC: Number of inseminations per cow in reproductive cycle $i + 1$ ($i = 0, ..., LL - 2$)

nl[i] Program EWDC: Ratio of days in lactation to calving interval in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

Nmc48a Program EWBC: Number of male calves staying alive 48 hours after calving per cow and reproductive cycle

Nmc48a[i] Program EWDC: Number of male calves staying alive 48 hours after calving per cow and reproductive cycle ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

Nmcba Program EWBC: Number of male calves born alive per cow and reproductive cycle

Nmcba[i] Program EWDC: Number of male calves born alive per cow and reproductive cycle ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

Nmcf Program EWBC: Number of male calves determined for fattening per cow and reproductive cycle

Nmcf[i] Program EWDC: Number of male calves reared and determined for fattening per cow and reproductive cycle ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

nmcf Program EWBC: Number of fattened bulls slaughtered before reaching target slaughter weight expressed as proportion of the total number of fattened bulls

nmcf[i] Program EWDC: Number of fattened bulls slaughtered before reaching target slaughter weight expressed as proportion of the total number of fattened bulls ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

Nmcfb Program EWBC: Number of male calves fattened as bulls per cow and reproductive cycle

Nmcfb[i] Program EWDC: Number of male calves fattened as bulls per cow and reproductive cycle ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

Nmcfc Program EWBC: Number of male calves fattened as castrates per cow and reproductive cycle

Nmcfc[i] Program EWDC: Number of male calves fattened as castrates per cow and reproductive cycle ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

Nmcw Program EWBC: Number of male calves weaned per cow and reproductive cycle

np[i] Program EWBC: Probability within the given reproductive cycle r that a cow which entered this cycle as a barren cow belongs to the given stage s (for more details see Section 2.2). Let r ($r = 1, ..., LL$) be the number of the reproductive cycle and s ($s = 1, ..., 6$ for $r < LL$ or $s = 1, .., 4$ for $r = LL$) the number of the stage, then $i = 6(r + 3) + s$ and

$$\sum_{i=6(r+3)+1}^{i=6(r+3)+S} np[i] = 1$$

for all r and $S = 6$ (for $r < LL$) or $S = 4$ (for $r = LL$). The variable is defined for $i = 25, ..., CC$.

npc[i] Program EWBC: Cows barren after the mating period in reproductive cycle $i + 1$ ($i = 0, ..., LL - 2$) expressed as proportion of cows calving in this cycle

npcsn[i] Program EWBC: Barren cows which stayed in the herd for the next mating period as proportion of all barren cows in reproductive cycle $i + 1$ ($i = 0, ..., LL - 2$) that entered this reproductive cycle as barren cows

npcsp[i] Program EWBC: Barren cows which stayed in the herd for the next mating period as proportion of all barren cows in cycle i+1 ($i = 0, ..., LL-2$) that entered this reproductive cycle as pregnant cows

nphs Program EWBC: Breeding heifers sold before mating expressed as proportion of surplus female calves

nphsold1 Program EWBC: Proportion of non-pregnant breeding heifers sold before the first mating period after their weaning

nphsold2 Program EWBC: Proportion of non-pregnant breeding heifers sold between the first and second mating period after their weaning

nprot Program EWDC: Number of thresholds for milk protein content in the milk pricing system

nr Number of re-inseminations per AI

nRCT Program EWDC: Number of thresholds for rennet coagulation time in the milk pricing system

NSCC Program EWDC: Maximal number of milk quality classes according to somatic cell content in the dairy cow population (set to 7)

nSCC Program EWDC: Number of milk quality classes according to somatic cell content in the dairy cow population

NT Number of traits + 1 (set to 30 in EWBC and to 40 in EWDC)

NTHR Program EWDC: Maximal number of threshold values for milk fat content, milk protein content, curd firmness or rennet coagulation time in the milk pricing system (set to 10)

P1 Maximal number of classes for fleshiness (set to 21)

p1 Number of classes for fleshiness

P2 Maximal number of classes for fat covering (set to 21)

p2 Number of classes for fat covering

pacd[i] Program EWDC: Number of claw diseases treated with antibiotics (veterinarian treatment) as proportion of all claw diseases per cow-year at risk in lactation $i + 1$, $i = 0, \ldots, LL - 1$ (in the whole calving interval)

paf[i] Program EWDC: Pure-bred ($i = 0$) or cross-bred ($i = 1$) animals (heifers, bulls or castrates) are present in fattening $paf[i] = 1$ or not $paf[i] = 0$

Pb[i][j] Program EWBC: Matrix of proportions (in per cent) of bull carcasses in the ith class of fleshiness and the jth class of fat covering; the elements of the matrix add up to 100

Pb[i][j][k] Program EWDC: Matrix of proportions (in per cent) of bull carcasses in commercial classes for fleshiness (i) and fat covering (j) for pure-bred ($k = 0$) or cross-bred animals ($k = 1$)

pbf Program EWBC: Bulls in fattening (1: yes, 0: no)

pbf[i] Program EWDC: Pure-bred ($i = 0$) or cross-bred ($i = 1$) bulls in fattening (1: yes, 0: no)

pc — Program EWDC: (when the cross-bred cows in System 3 came from System 4) Number of cross-bred cows in System 3 expressed as proportion of dairy cows in System 4 (that means per dairy cow in System 4)

Pc[i][j] — Program EWBC: Matrix of proportions (in per cent) of cow carcasses in the ith class of fleshiness and the jth class of fat covering; the elements of the matrix add up to 100

Pc[i][j][k] — Program EWDC: Matrix of proportions (in per cent) of cow carcasses in the ith class of fleshiness and the $j$class of fat covering for pure-bred ($k = 0$) or cross-bred animals ($k = 1$); the elements of the matrix add up to 100[14]

Pc0[i][j] — Program EWBC: Temporary variable needed for the calculation of economic weights of fleshiness and fat covering

Pc0[i][j][k] — Program EWDC: Temporary variable needed for the calculation of economic weights of fleshiness and fat covering

pcal[i] — Program EWBC: Calved cows (pregnant in the previous reproductive cycle) in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$) expressed as proportion of all cows entered this cycle

pcalc[i] — Program EWBC: Calved cows (pregnant in the previous reproductive cycle) in category i ($i = 25, ..., CC$) as proportion of all cows in this category

pcdys[i] — Probability that a cow will be culled due to health problems after dystocia in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

Pcfc[j] — Program EWBC: Needed for the calculation of the economic weight for fat covering

Pcfc[j][k] — Program EWDC: Needed for the calculation of the economic weight for fat covering

Pcfcd[j] — Program EWBC: Needed for the calculation of the economic weight for fat covering

Pcfcd[j][k] — Program EWDC: Needed for the calculation of the economic weight for fat covering

Pcfcdl[j] — Program EWBC: Needed for the calculation of the economic weight for fat covering

Pcfcdl[j][k] — Program EWDC: Needed for the calculation of the economic weight for fat covering

Pcfcdr[j] — Program EWBC: Needed for the calculation of the economic weight for fat covering

Pcfcdr[j][k] — Program EWDC: Needed for the calculation of the economic weight for fat covering

Pcfcl[j] — Program EWBC: Needed for the calculation of the economic weight for fat covering

Pcfcl[j][k] — Program EWDC: Needed for the calculation of the economic weight for fat covering

[14] In the modelled system, only pure-bred cows occur and the matrix is calculated only for $k = 0$.

Pcfcmc Program EWBC: Needed for the calculation of the economic weight for fat covering

Pcfcmc[k] Program EWDC: Needed for the calculation of the economic weight for fat covering

Pcfcmcb Program EWBC: Mean class for fat covering in bulls

Pcfcmcb[k] Program EWDC: Mean class for fat covering in pure-bred dairy ($k = 0$) or cross-bred ($k = 1$) bulls

Pcfcmcc Program EWBC: Mean class for fat covering in cows

Pcfcmcc[k] Program EWDC: Mean class for fat covering in pure-bred dairy ($k = 0$) or cross-bred ($k = 1$) cows[15]

Pcfcmcca Program EWBC: Mean class for fat covering in castrates

Pcfcmcca[k] Program EWDC: Mean class for fat covering in pure-bred dairy ($k = 0$) or cross-bred ($k = 1$) castrates

Pcfcmch Program EWBC: Mean class for fat covering in heifers

Pcfcmch[k] Program EWBC: Mean class for fat covering in pure-bred dairy ($k = 0$) or cross-bred ($k = 1$) heifers

Pcfcql[j] Program EWBC: Needed for the calculation of the economic weight for fat covering

Pcfcql[j][k] Program EWDC: Needed for the calculation of the economic weight for fat covering

Pcfcqm[j] Program EWBC: Needed for the calculation of the economic weight for fat covering

Pcfcqm[j][k] Program EWDC: Needed for the calculation of the economic weight for fat covering

Pcfcqr[j] Program EWBC: Needed for the calculation of the economic weight for fat covering

Pcfcqr[j][k] Program EWDC: Needed for the calculation of the economic weight for fat covering

Pcfcr[j] Program EWBC: Needed for the calculation of the economic weight for fat covering

Pcfcr[j][k] Program EWDC: Needed for the calculation of the economic weight for fat covering

Pcfl[i] Program EWBC: Needed for the calculation of the economic weight for fleshiness

Pcfl[i][k] Program EWDC: Needed for the calculation of the economic weight for fleshiness

Pcfld[i] Program EWBC: Needed for the calculation of the economic weight for fleshiness

[15] Only calculated for pure-bred dairy cows

Pcfld[i][k] Program EWDC: Needed for the calculation of the economic weight for fleshiness

Pcfldl[i] Program EWBC: Needed for the calculation of the economic weight for fleshiness

Pcfldl[i][k] Program EWDC: Needed for the calculation of the economic weight for fleshiness

Pcfldr[i] Program EWBC: Needed for the calculation of the economic weight for fleshiness

Pcfldr[i][k] Program EWDC: Needed for the calculation of the economic weight for fleshiness

Pcfll[i] Program EWBC: Needed for the calculation of the economic weight for fleshiness

Pcfll[i][k] Program EWDC: Needed for the calculation of the economic weight for fleshiness

Pcflmc Program EWBC: Needed for the calculation of the economic weight for fleshiness

Pcflmc[k] Program EWDC: Needed for the calculation of the economic weight for fleshiness

Pcflmcb Program EWBC: Mean class for fleshiness in bulls

Pcflmcb[k] Program EWDC: Mean class for fleshiness in pure-bred dairy ($k = 0$) or cross-bred ($k = 1$) bulls

Pcflmcc Program EWBC: Mean class for fleshiness in cows

Pcflmcc[k] Program EWDC: Mean class for fleshiness in pure-bred dairy ($k = 0$) or cross-bred ($k = 1$) cows[16]

Pcflmcca Program EWBC: Mean class for fleshiness in castrates

Pcflmcca[k] Program EWDC: Mean class for fleshiness in pure-bred dairy ($k = 0$) or cross-bred ($k = 1$) castrates

Pcflmch Program EWBC: Mean class for fleshiness in heifers

Pcflmch[k] Program EWDC: Mean class for fleshiness in pure-bred dairy ($k = 0$) or cross-bred ($k = 1$) heifers

Pcflql[i] Program EWBC: Needed for the calculation of the economic weight for fleshiness

Pcflql[i][k] Program EWDC: Needed for the calculation of the economic weight for fleshiness

Pcflqm[i] Program EWBC: Needed for the calculation of the economic weight for fleshiness

Pcflqm[i][k] Program EWDC: Needed for the calculation of the economic weight for fleshiness

[16] Only calculated for pure-bred dairy cows

Pcflqr[i] Program EWBC: Needed for the calculation of the economic weight for fleshiness

Pcflqr[i][k] Program EWDC: Needed for the calculation of the economic weight for fleshiness

Pcflr[i] Program EWBC: Needed for the calculation of the economic weight for fleshiness

Pcflr[i][k] Program EWDC: Needed for the calculation of the economic weight for fleshiness

pchf Program EWBC: Castrates **and** heifers in fattening (Yes: $pchf = 1$, no: $pchf = 0$)

pclos[i] Program EWBC: Cow losses within reproductive cycle i+1 ($i = 0, ..., LL-1$), $pclos[i] = pp[25 + 6i]$

pcmf Program EWBC: Fattened castrates expressed as proportion of male calves intended for fattening

pcmf[i] Program EWDC: Fattened castrates expressed as proportion of male calves intended for fattening ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

pconc[i][j] Program EWDC: Cows conceiving in reproductive cycle $i + 1$ after the jth insemination as proportion of all conceived cows in reproductive cycle $i + 1$ ($i = 0, ..., LL - 2$)

pconh[j] Program EWDC: Heifers conceiving after the jth insemination as proportion of all conceived heifers

pcross[i] Program EWDC: Dairy cows in reproductive cycle i+1 ($i = 0, ..., LL-2$) mated with beef bulls as proportion of all mated dairy cows in the given reproductive cycle

pcrossh Program EWDC: Dairy heifers mated with beef bulls as proportion of all mated dairy heifers

Pcs[i][j] Program EWBC: Matrix of proportions (in per cent) of castrate carcasses in the ith class of fleshiness and the $j$class of fat covering; the elements of the matrix add up to 100

Pcs[i][j][k] Program EWDC: Matrix of proportions (in per cent) of castrate carcasses in the ith class of fleshiness and the $j$class of fat covering for pure-bred ($k = 0$) or cross-bred animals ($k = 1$); the elements of the matrix add up to 100

pcul[i] Program EWBC: Cows culled within reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$) as proportion of all cows entered the cycle

pdi[i] Total protein requirement per animal of category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

pdi10 Program EWDC: Protein requirement per animal of category 10 from the end of the rearing period of calves till selling

pdi2[i] Program EWDC: Protein requirement per calf of category i ($i = 3, 8, 9, 10, CC+3, CC + 8, CC + 9, CC + 10$) in the second feeding period

pdias[i] Program EWBC: Protein requirement for reaching the required slaughter weight of extensively fattened animals per animal of category i ($i = 12, 17$) after the summer fattening period on pasture

pdibbm Program EWBC: Protein requirement per breeding bull from purchase to reaching mature weight

pdibbs Program EWBC: Protein requirement per breeding bull from summer feed ration from purchase to slaughter

pdibbsl Program EWBC: Protein requirement per breeding bull from summer feed ration from reaching mature weight to slaughter

pdibbw Program EWBC: Protein requirement per breeding bull from winter feed ration from purchase to slaughter

pdid[i] Program EWDC: Protein content per kg dry matter of feed ration for animals of category i ($i = 1, ..., CT$)

pdid10 Program EWDC: Protein content per kg dry matter of feed ration for breeding bulls from the end of the rearing period of calves till selling

pdid2[i] Program EWDC: Protein content per kg dry matter of feed ration for calves of category i ($i = 3, 8, 9, 10, CC+3, CC+8, CC+9, CC+10$) in the second feeding period

pdidf[i] Program EWBC: Protein content per kg dry matter of feed ration for intensively fattened animals of category i ($i = 4, 5, 6, 12, 13, 14, 15, 16, 17$)

pdidfx[i] Program EWBC: Protein content per kg dry matter of feed ration for fattened animals of category i ($i = 12, 17$) in the period after extensive fattening on pasture

pdids[i] Program EWBC: Protein content per kg dry matter of summer feed ration for animals of category i ($i = 1, ..., CC$ except $i = 4, 14, 15$)

pdidt Program EWBC: Protein content per kg dry matter of summer feed ration for breeding bulls in the performance test

pdidtb Program EWBC: Protein content per kg dry matter of feed ration for breeding bulls in the herd from weaning to the start of the performance test

pdidtse Program EWBC: Protein content per kg dry matter of winter feed ration for breeding bulls from the end of the performance test to selling

pdidw[i] Program EWBC: Protein content per kg dry matter of winter feed ration for animals of category i ($i = 1, ..., CC$ except $i = 4, 14, 15$)

pdidwf[i] Program EWDC: Protein content per kg dry matter of feed ration for female calves in the first feeding period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

pdidwf2[i] Program EWDC: Protein content per kg dry matter of feed ration for female calves in the second feeding period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

pdidwm[i] Program EWDC: Protein content per kg dry matter of feed ration for male calves in the first feeding period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

pdidwm2[i] Program EWDC: Protein content per kg dry matter of feed ration for male calves in the second feeding period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

pdig[i] Program EWDC: Protein requirement for growth per cow of category i ($i = 25, ...CC$)

pdigs[i] rogram EWBC: Protein requirement per cow of category i ($i = 25, ..., CC$) for growth in the summer feeding period

pdigw[i] Program EWBC: Protein requirement per cow of category i ($i = 25, ..., CC$) for growth in the winter feeding period

pdil[i] Program EWDC: Protein requirement for lactation per cow of category i ($i = 25, ...CC$)

pdim[i] Program EWDC: Protein requirement for maintenance per cow of category i ($i = 25, ...CC$)

pdiml Program EWDC: Protein requirement per kg milk with given fat and protein percentage

pdims[i] Program EWBC: Protein requirement per cow of category i ($i = 25, ..., CC$) for maintenance in the summer feeding period

pdimw[i] Program EWBC: Protein requirement per cow of category i ($i = 25, ..., CC$) for maintenance in the winter feeding period

pdipc[i] Total protein requirement for pregnancy per animal of category i ($i = 20, 22, 25, ..., CC$)

pdis[i] Program EWBC: Protein requirement per animal of category i ($i = 1, ..., CC + 10$ except $4, 14, 15$) in the summer feeding period

pdis0[i] Program EWBC: Protein requirement in the "zeroth" summer feeding period[17] after weaning per animal of category i ($i = CC+1, ..., CC+10$)

pdis1[i] Program EWBC: Protein requirement in the 1st summer feeding period after weaning per animal of category i ($i = CC + 2, ..., CC + 6, CC + 8, CC + 10$)

pdis2[i] Program EWBC: Protein requirement in the 2nd summer feeding period after weaning per animal of category i ($i = CC+2, CC+3, CC+5, CC+6, CC + 10$)

pdis3[i] Program EWBC: Protein requirement in the 3rd summer feeding after weaning period per animal of category i ($i = CC + 3, CC + 6$)

pdiscal[i] Program EWBC: Total protein requirement from summer feeding per cow of category i ($i = 25, ..., CC$) that had calved in the given reproductive cycle

pdisl[i] Program EWBC: Protein available for a calf of category i ($i = 3, 8, 9$) in the summer period from cows' milk

pdisncal[i] Program EWBC: Total protein requirement from summer feeding per cow of category i ($i = 25, ..., CC$) that had not calved in the given reproductive cycle

[17] This period occurs only if calves are weaned before the end of the pasture period.

pdisp[i] Program EWBC: Protein requirement for pregnancy in the summer period per animal of category i ($i = 20, 22, 25, ..., CC + 10$)

pdit Program EWBC: Protein requirement per bull in the performance test

pditb Program EWBC: Protein requirement per bull from weaning to the start of the performance test

pditse Program EWBC: Protein requirement per breeding bull from the end of the performance to selling

pdiw[i] Program EWBC: Protein requirement per animal of category i ($i = 1, ..., CC + 10$ except $4, 14, 15$) in the winter feeding period

pdiw1[i] Program EWBC: Protein requirement in the 1st winter feeding period after weaning per animal of category i ($i = CC + 2, ..., CC + 6, CC + 8, CC + 10$)

pdiw2[i] Program EWBC: Protein requirement in the 2nd winter feeding period after weaning per animal of category i ($i = CC + 2, ..., CC + 6, CC + 8, CC + 10$)

pdiw3[i] Program EWBC: Protein requirement in the 3rd winter feeding period after weaning per animal of category i ($i = CC + 3, CC + 5, CC + 6$)

pdiw4 Program EWBC: Protein requirement in the 4th winter feeding period after weaning per animal of category $CC + 6$

pdiwcal[i] Program EWBC: Total protein requirement from winter feeding per cow of category i ($i = 25, ..., CC$) that had calved in the given reproductive cycle

pdiwf[i] Program EWDC: Protein requirement per female calf from birth to the end of the first feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

pdiwf2[i] Program EWDC: Protein requirement per female calf in the second feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

pdiwl[i] Program EWBC: Protein available per calf of category i ($i = 3, 8, 9$) in the winter period from cows' milk ($i = 25, ..., CC$)

pdiwm[i] Program EWDC: Protein requirement per male calf from birth to the end of the first feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

pdiwm2[i] Program EWDC: Protein requirement per male calf in the second feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

pdiwncal[i] Program EWBC: Total protein requirement in the winter feeding period per cow of category i ($i = 25, ..., CC$) that had not calved in the given reproductive cycle

pdiwp[i] Program EWBC: Protein requirement for pregnancy in the winter feeding periods per animal of category i ($i = 20, 22, 25, ..., CC$)

pdiwp1[i] Program EWBC: Protein requirement for pregnancy in the first winter feeding period per animal of category i ($i = 20, 22, 25, ..., CC$)

pdiwp2[i] Program EWBC: Protein requirement for pregnancy in the second winter feeding period per animal of category i ($i = 20, 22, 25, ..., CC$)

pdry Program EWDC: Proportion of cows that are dried with antibiotics

pf[i] Program EWBC: Probability that a conceived cow will bear a dead female calf ($i = 1$) or probability that a born female calf dies within 48 hours after calving ($i = 2$)

pf[j][i] Program EWDC: Probability that a conceived cow will bear a dead female calf ($i = 1$) or probability that a born female calf dies within 48 hours after calving ($i = 2$), ($j = 0$: pure-bred animals, $j = 1$: cross-bred animals)

pff Program EWBC: Female calves for fattening as proportion of surplus female calves

pff[i] Program EWDC: There are female pure-bred ($i = 0$) or cross-bred calves ($i = 1$) in fattening ($pff[i] = 1$) or not ($pff[i] = 0$)

Ph[i][j] Program EWBC: Matrix of proportions (in per cent) of heifer carcasses in the ith class of fleshiness and the jth class of fat covering; the elements of the matrix add up to 100

Ph[i][j][k] Program EWDC: Matrix of proportions (in per cent) of heifer carcasses in the ith class of fleshiness and the $j$class of fat covering for pure-bred ($k = 0$) or cross-bred animals ($k = 1$); the elements of the matrix add up to 100

phc1 Program EWBC: Heifers culled because of no pregnancy after the 1st mating period after their weaning expressed as proportion of all culled not pregnant heifers

phc2 Program EWBC: eifers culled because of no pregnancy after the 2nd mating period after their weaning expressed as proportion of all culled not pregnant heifers

phc3 Program EWBC: Heifers culled because of no pregnancy after the 3rd mating period after their weaning expressed as proportion of all culled not pregnant heifers

Phiscc[i] Program EWDC: Cumulative frequency up to the ith class of milk quality due to somatic cell count ($i = 0, ..., nSCC - 2$)

phmat1 Program EWBC: eifers mated in the 1st mating period after their weaning (on the basis of reaching the minimal weight for mating) as proportion of all weaned female calves intended for replacement

phmat2 Program EWBC: Heifers mated in the 2nd mating period after their weaning as proportion of all female calves intended for replacement

php1 Program EWBC: Heifers pregnant after the 1st mating period after their weaning as proportion of all pregnant heifers

php2 Program EWBC: Heifers pregnant after the 2nd mating period after their weaning as proportion of all pregnant heifers

php3 Program EWBC: Pregnant heifers sold expressed as proportion of surplus female calves

phs Program EWBC: Pregnant heifers sold expressed as proportion of surplus female calves

pinmatd[i] Program EWBC: Cows having dystocia that were mated in the 1st oestrus within reproductive cycle $i+1$ ($i = 0, ..., LL-2$) as proportion of all mated cows having dystocia in this cycle

pinmatnd[i] Program EWBC: Cows without dystocia that were mated in the 1st oestrus within reproductive cycle $i+1$ ($i = 0, ..., LL-2$) as proportion of all mated cows not having dystocia in this cycle

pl Program EWBC: Expected milk production level of the herd (1 - lowest, 9 - highest)

pm[i] Program EWBC: Probability that a conceived cow will bear a dead male calf ($i = 1$) or probability that a born male calf dies from calving to 48 hours after calving ($i = 2$)

pm[j][i] Program EWDC: Probability that a conceived cow will bear a dead male calf ($i = 1$) or probability that a born male calf dies from calving to 48 hours after calving ($i = 2$), ($j = 0$: pure-bred animals, $j = 1$: cross-bred animals)

PM[i][j] Gene transmission matrix for gene flow (see Section 2.8)

pncal[i] Program EWBC: Calved cows (not pregnant in the previous cycle) in reproductive cycle $i+1$ ($i = 0, ..., LL-2$) as proportion of all cows which entered this cycle

pncalc[i] Program EWBC: Calved cows (not pregnant in previous cycle) in category i ($i = 25, ..., CC$) as proportion of all cows in this category

pp[i] Program EWBC: Probability within the given reproductive cycle r that a cow which entered this cycle as a pregnant cow belongs to the given stage s (for more details see Section 2.2). Let r ($r = 1, ..., LL$) be the number of the reproductive cycle and s ($s = 1, ..., 6$ for $r < LL$ or $s = 1, .., 4$ for $r = LL$) the number of the stage, then $i = 6(r+3) + s$ and

$$\sum_{i=6(r+3)+1}^{i=6(r+3)+S} pp[i] = 1$$

for all r and $S = 6$ (for $r < LL$) or $S = 4$ (for $r = LL$). The variable is defined for $i = 25, ..., CC$

pr[i] Price per kg live weight for living animals or per kg carcass for fattened animals of category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

prai Program EWBC: Price per portion of semen for AI

praib Program EWDC: Price per portion of semen for AI from beef bulls

praid Program EWDC: Price per portion of semen for AI from dairy bulls

prair Program EWBC: Cost per re-insemination

prairb Program EWDC: Cost per re-insemination from beef bulls

praird Program EWDC: Cost per re-insemination from dairy bulls

pranim[i] Program EWDC: Price per animal ($i = 8, 9, 10, 23, 24, CC + 8, CC + 9, CC + 10, CC + 23, CC + 24$)

pras[i] Program EWBC: Price per kg fresh matter of the feed ration in the fattening period after extensive fattening on pasture for animals of category i ($i = 5, 6, 12, 13, 16, 17$)

prb Price per kg carcass of bulls in the base class of fleshiness and fat covering

Prb[i][j] Matrix of coefficients of carcass prices for bulls in the ith class of fleshiness and jth class of fat covering relative to the price in the base class of fleshiness and fat covering

prbb Program EWBC: Price per breeding bull purchased for natural mating

prbbcull Program EWBC: Price per kg carcass weight of old breeding bulls

prbbsel Program EWBC: Price per performance tested and selected breeding bull

prc Price per kg carcass of cows in the base class for fleshiness and fat covering

Prc[i][j] Matrix of coefficients of carcass prices for cows in the ith class of fleshiness and jth class of fat covering relative to the price in the base class of fleshiness and fat covering

prcs Price per kg carcass of castrates in the base class for fleshiness and fat covering

Prcs[i][j] Matrix of coefficients of carcass prices for castrates in the ith class of fleshiness and jth class of fat covering relative to the price in the base class of fleshiness and fat covering

prdg Price per kg dung

preg2nmc[i] Program EWBC: Cows conceived in the 2nd oestrus in the mating period as proportion of all pregnant cows in reproductive cycle $i + 1$ ($i = 0, ..., LL - 2$)

preg2nmh Program EWBC: Heifers conceived in the 2nd oestrus in the mating period as proportion of all pregnant heifers in this mating period

preg3nmc[i] Program EWBC: Cows conceived in the 3rd oestrus in the mating period as proportion of all pregnant cows in reproductive cycle $i + 1$ ($i = 0, ..., LL - 2$)

preg3nmh Program EWBC: Heifers conceived in the 3rd oestrus in the mating period as proportion of all pregnant heifers in this mating period

pregaic[i] Program EWBC: Cows conceived in the 1st oestrus in the mating period as proportion of all pregnant cows in reproductive cycle $i + 1$ ($i = 0, ..., LL - 2$)

pregaih Program EWBC: Heifers conceived in the 1st oestrus in the mating period as proportion of all pregnant heifers in this mating period

prf[i] Program EWBC: Price per kg fresh matter of the feed ration in intensive fattening for animals of category i ($i = 4-6, 12-17$), Program EWDC: Price per kg fresh matter of the feed ration for animals of category i ($i = 1, ...CT$)

prf10 Program EWDC: Price per kg fresh matter of feed ration for breeding bulls from the end of the rearing period of calves till selling

prf2[i] Program EWDC: Price per kg fresh matter of the feed ration for reared calves of category i ($i = 3, 8, 9, 10, CC+3, CC+8, CC+9, CC+10$) in the second feeding period

prfwf[i] Program EWDC: Price per kg fresh matter of the feed ration for female calves in the first feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

prfwf2[i] Program EWDC: Price per kg fresh matter of the feed ration for female calves in the second feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

prfwm[i] Program EWDC: Price per kg fresh matter for male calves in the first feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

prfwm2[i] Program EWDC: Price per kg fresh matter of the feed ration for male calves in the second feeding period in rearing calves ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

prh Price per kg carcass for heifers in the base class for fleshiness and fat covering

Prh[i][j] Matrix of coefficients of carcass prices for heifers in the ith class of fleshiness and jth class of fat covering relative to the price of the base class of fleshiness and fat covering

prherdcd Program EWDC: Value of the herdman's (or trimmer) time

pricedry Program EWDC: Price per dose of drug for drying cows

priceherd Program EWDC: Value of herdsman's time in monetary units per hour

pricevet Program EWDC: Average charge for veterinary service (per hour)

prm[i] Program EWBC: Price per kg minerals for animals of category i ($i = 1, ..., CC$ except $4, 14, 15$)

prmilk Program EWDC: Price per kg milk of given fat and protein content and given somatic cell count

prmilka30[i] Program EWDC: Bonus or penalty for curd firmness per kg milk in the ith class of curd firmness ($i = 0, ..., na30$)

prmilkb Program EWDC: Base milk price per kg milk

prmilkf[i] Program EWDC: Bonus or penalty for fat content per kg milk in the ith class of fat content ($i = 0, ..., nfat$)

prmilkfp Program EWDC: Milk price adjusted for fat and protein content, rennet coagulation time and curd firmness and not yet adjusted for milk quality classes according to SCC (per kg milk)

prmilkp[i] Program EWDC: Bonus or penalty for protein content per kg milk in the ith class of protein content ($i = 0, ..., nprot$)

prmilkRCT[i] Program EWDC: Bonus or penalty for rennet coagulation time per kg milk in the ith class of rennet coagulation time ($i = 0, ..., nRCT$)

prnphse	Program EWBC: Price per kg live weight of not mated breeding heifers
prodsys	Production system (takes values 1 to 4, see Section 4.1.1.1)
prodsys2	Program EWDC: production system (takes values 1 to 3, see Section 4.1.1.1) for which the data for the file FROM1_3.TXT were calculated
profitab	Profitability without governmental subsidies
profitabd	Profitability including governmental subsidies
prot	Protein content in milk
prot305ave	Program EWDC: 305d protein yield (kg)
protkg	Program EWDC: Protein yield (kg) produced over the whole lactation
prphse	Program EWBC: Price per kg live weight of pregnant breeding heifers at selling
prrep	Program EWBC: Price per kg live weight of pregnant breeding heifers purchased for replacement
prs[i]	Program EWBC: Price per kg fresh matter of summer feed ration for category i ($i = 1, ..., CC$ except $i = 4, 14, 15$)
prscc	Program EWDC: Temporary variable for calculating the milk price
prSCC[i]	Program EWDC: Vector of basic prices per kg milk in quality class i ($i = 1, ...NSCC$)
prst	Price per kg straw
prt	Program EWBC: Price per kg fresh matter of feed ration for breeding bulls in the performance test
prtb	Program EWBC: Price per kg fresh matter of feed ration for breeding bulls before the performance test
prtse	Program EWBC: Price per kg fresh matter of feed ration for breeding bulls from the end of the performance test to selling
prvetcd	Program EWDC: Average charge per hour for the veterinary service
prw[i]	Program EWBC: Price per kg fresh matter of winter feed ration for animals of category i ($i = 1, ..., CC$ except $i = 4, 14, 15$)
prwt	Price per l water
pSCC[i]	Program EWDC: Vector of proportions of sold milk in quality class i ($i = 1, ..., nSCC$)
psum	Program EWDC: Number of progeny per cow and reproductive cycle
p_tot[i]	Program EWDC: Number of progeny of category i ($i = 1, ..., 24$) (Sum of pure-bred and cross-bred progeny)
pydry	Program EWDC: Proportion of cows that are dried with antibiotics per cow and year
qc[i]	Discounting coefficient for cost for category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

qr[i] Discounting coefficient for revenues for category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

ra30[i][j] Program EWDC: Coefficients for the regression of the milk price on curd firmness. $i = 0$: intercept, $i = 1$: linear regression coefficient; j ($j = 0, ..., na30$) refers to the class for curd firmness.

RCT Program EWDC: Rennet coagulation time

rev[i] Revenues per animal of category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

revc Program EWDC: Total revenues per cow and year (summed *only* over all *cow categories*)

revcullc Program EWDC: Revenues from culled cows summed over all cow categories, per cow and year

revmilk[i] Program EWDC: Revenues from milk per cow of category i ($i = 25, ...CC$)

revmilkc Program EWDC: Revenues from milk from all cow categories per cow and year

rf[i][j] Program EWDC: Coefficients for the regression of the milk price on milk fat content. $i = 0$: intercept, $i = 1$: linear regression coefficient; j ($j = 0, ..., nfat$) refers to the class for fat content.

rfi[i] Program EWDC: Residual daily dry matter intake of category i, $i = 1, \ldots, CT$. The dry matter intake refers only to the first feeding period in calves. Program EWBC: Residual daily dry matter intake of category i in intensive fattening.

rfi2[i] Program EWDC: Residual daily dry matter intake of calves of category i in the second feeding period ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9, CC + 10$)

rfi10 Program EWDC: Average residual daily dry matter intake of breeding bulls from the end of the rearing period of calves till selling (the difference between the daily actual and predicted dry matter intake)

rfi_calf Program EWDC: Indicator variable if economic value for residual dry matter intake of calves in rearing is calculated or not.

rfi_cow Program EWDC: Indicator variable if economic value for residual dry matter intake of cows is calculated or not; Program EWBC: Indicator variable if economic value for residual dry matter intake of adult animals is calculated or not

rfi_f Program EWBC: Indicator variable if economic value for residual dry matter intake of animals in (intensive or extensive) fattening is calculated or not

rfi_fa Program EWDC: Indicator variable if economic value for residual dry matter intake of animals in fattening is calculated or not. Program EWBC: Indicator variable if economic value for residual dry matter intake of animals in intensive fattening is calculated or not

rfifc1[i] Program EWDC: Residual daily dry matter intake of the of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves in the first feeding period

rfifc2[i] Program EWDC: Residual daily dry matter intake of the of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves in the second feeding period

rfi_fx Program EWBC: Indicator variable if economic value for residual dry matter intake of animals in extensive fattening is calculated or not

rfi_h Indicator variable if economic value for residual dry matter intake of heifers in rearing is calculated or not.

rfimc1[i] Program EWDC: Residual daily dry matter intake of the of pure-bred ($i = 0$) and cross-bred ($i = 1$) male calves in the first feeding period

rfimc2[i] Program EWDC: Residual daily dry matter intake of the of pure-bred ($i = 0$) and cross-bred ($i = 1$) male calves in the second feeding period

rfis[i] Program EWBC: Residual daily dry matter intake of animal category i ($i = 1, ..., CC$ except fattened bulls and calves till weaning) in summer feeding period

rfisc Program EWBC: Average residual daily dry matter intake of fattened castrates after pasture

rfisf Program EWBC: Average residual daily dry matter intake of fattened heifers after pasture

rfit Program EWBC: Residual daily dry matter intake of breeding bulls in the performance test (only for production system 1)

rfitb Program EWBC: Residual daily dry matter intake of breeding bulls from weaning to starting performance test (only for production system 1)

rfits Program EWBC: Residual daily dry matter intake of breeding bulls from the end of performance test till selling (only for production system 1)

rfiw[i] Program EWBC: Residual daily dry matter intake of animal category i ($i = 1, ..., CC$ except fattened bulls and calves till weaning) in the winter feeding period

rp[i][j] Program EWDC: Coefficients for the regression of the milk price on milk protein content. $i = 0$: intercept, $i = 1$: linear regression coefficient; j ($j = 0, ..., nprot$) refers to the class for protein content.

rRCT[i][j] Program EWDC: Coefficients for the regression of the milk price on rennet coagulation time. $i = 0$: intercept, $i = 1$: linear regression coefficient; j ($j = 0, ..., nRCT$) refers to the class for rennet coagulation time.

sdcd Sum of the vector $dcd[i]$

sdce Sum of the vector $dce[i]$

sfrp Program EWBC: Heifers negatively selected on health and exterior before mating as proportion of reared heifers

sfrp[i] Program EWDC: Heifers negatively selected on health and exterior before mating as proportion of reared heifers ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

sigmaa30 Program EWDC: Phenotypic standard deviation for curd firmness

sigmafat Program EWDC: Phenotypic standard deviation for milk fat content

sigmaprot Program EWDC: Phenotypic standard deviation for milk protein content

sigmaRCT Program EWDC: Phenotypic standard deviation for rennet coagulation time

sigmaSCS Program EWDC: Phenotypic standard deviation of somatic cell score in the dairy cow population

sigmawh Program EWBC: Phenotypic standard deviation of the weight of heifers at first mating (at an age of about 1 year)

sl_1[i] Program EWBC: Average amount of milk in kg produced per cow in the summer period in reproductive cycle 1 available for calves of category i ($i = 3, 8, 9$)

sl_2[i] Program EWBC: Average amount of milk in kg produced per cow in the summer period in reproductive cycle 2 available for calves of category i ($i = 3, 8, 9$)

sl_3[i] Program EWBC: Average amount of milk in kg produced per cow in the summer period in reproductive cycle 3 available for calves of category i ($i = 3, 8, 9$)

sl[i] Program EWBC: Average amount of milk in kg produced per cow in the summer period (according to the age structure of the cows in the herd) available for calves of category i ($i = 3, 8, 9$)

sl2 Sum of elements of vector **l2**

sp[i] Program EWDC: Service period of cows of category i ($i = 25, ...CC-3$)

startbt Program EWBC: Starting date for the performance test of bulls (only in Production System 1)

stcd[i] Still-born calves after dystocia as proportion of cows having dystocia in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

stce[i] Still-born calves after easy calving as proportion of cows having easy calving in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

straw[i] Program EWBC: Daily amount of straw per animal of category i ($i = 1, ..., CC$) during the winter housing period. Program EWDC: Daily amount of straw per animal of category i ($i = 1, ..., CT$)

straw10 Program EWDC: Daily amount of straw per breeding bull per day

strawbb Program EWBC: Daily amount of straw per breeding bull in the herd during the winter housing period

strawfi Program EWBC: Daily amount of straw per animal in intensive fattening

strawfx Program EWBC: Daily amount of straw per animal in extensive fattening during the winter housing period

strawwf[i] Program EWDC: Daily amount of straw per female calf in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

strawwm[i] Program EWDC: Daily amount of straw per male calf in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

suml1 Program EWBC: Sum of elements of vector **l1**

T Maximal number of cow categories + 1 (set to 119 in EWBC and to 89 in EWDC)

t[i][j] Program EWBC: Elements of the transmission matrix for the calculation of the herd structure ($i, j = 1, ..., TT$)

tc[i] Length of the time period (in years) from calving to the time when the costs in category i occur (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

tconh3 Program EWDC: Total conception rate of heifers in System 3

Tcost Total cost per cow entering the reproductive cycle (per cow and year)

tdry[i] Program EWDC: Predicted total dry matter intake of category i ($i = 1, ..., CT$). For calves ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9, CC + 10$), the total dry matter intake refers to the first feeding period only. Program EWBC: Predicted total dry matter intake of animal category i in intensive fattening ($i = 4, 5, 6, 12 - 17$).

tdry2[i] Program EWDC: Predicted total dry matter intake of calves of category i in the second feeding period ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9, CC + 10$)

tdry10 Program EWDC: Predicted total dry matter intake of breeding bulls in the third feeding period (category 10)

trybbs Program EWBC: Predicted total dry matter intake of breeding bulls for natural mating in the summer feeding period

trybbse Program EWBC: Predicted total dry matter intake of breeding bulls for natural mating in the summer feeding period calculated on the basis of energy requirement

trybbspdi Program EWBC: Predicted total dry matter intake of breeding bulls for natural mating in the summer feeding period calculated on the basis of protein requirement

trybbw Program EWBC: Predicted total dry matter intake of breeding bulls for natural mating in the winter feeding period

trybbwe Program EWBC: Predicted total dry matter intake of breeding bulls for natural mating in the winter feeding period calculated on the basis of energy requirement

trybbwpdi Program EWBC: Predicted total dry matter intake of breeding bulls for natural mating in the winter feeding period calculated on the basis of protein requirement

tdrye[i] Program EWDC: Predicted total dry matter intake of category i ($i = 1, ..., CT$) calculated on the basis of energy requirement. For calves ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9, CC + 10$), the total dry matter intake refers to the first feeding period only. Program EWBC: Predicted total dry matter intake of animal category i in intensive fattening ($i = 4, 5, 6, 12 - 17$) calculated on the basis of energy requirement

tdrye2[i] Program EWDC: Predicted total dry matter intake of calves category i in the second feeding period ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9, CC + 10$) calculated on the basis of energy requirement

tdrye10 Program EWDC: Predicted total dry matter intake of breeding bulls in the third feeding period (category 10) calculated on the basis of energy requirement

tdryewf[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves in the first feeding period calculated on the basis of energy requirement

tdryewf2[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves in the second feeding period calculated on the basis of energy requirement

tdryewm[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) male calves in the first feeding period calculated on the basis of energy requirement

tdryewm2[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) male calves in the second feeding period calculated on the basis of energy requirement

tdryfas[i] Program EWBC: Predicted total dry matter intake of extensively fattened animals of category i ($i = 12, 17$) in the last feeding period after pasture (if this period exists)

tdryfase[i] Program EWBC: Predicted total dry matter intake of extensively fattened animals of category i ($i = 12, 17$) in the last feeding period after pasture (if this period exists) calculated on the basis of energy requirement.

tdryfaspdi[i] Program EWBC: Predicted total dry matter intake of extensively fattened animals of category i ($i = 12, 17$) in the last feeding period after pasture (if this period exists) calculated on the basis of protein requirement.

tdrypdi[i] Program EWDC: Predicted total dry matter intake of category i ($i = 1, ..., CT$) calculated on the basis of protein requirement. For calves ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9, CC + 10$), the total dry matter intake refers to the first feeding period only. Program EWBC: Predicted total dry matter intake of animal category i in intensive fattening ($i = 4, 5, 6, 12 - 17$) calculated on the basis of protein requirement.

tdrypdi2[i] Program EWDC: Predicted total dry matter intake of calves of category i in the second feeding period ($i = 3, 8, 9, 10, CC + 3, CC + 8, CC + 9, CC + 10$) calculated on the basis of protein requirement

tdrypdi10 Program EWDC: Predicted total dry matter intake of breeding bulls in the third feeding period (category 10) calculated on the basis of protein requirement

tdrypdiwf[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves in the first feeding period calculated on the basis of protein requirement

tdrypdiwf2[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves in the second feeding period calculated on the basis of protein requirement

tdrypdiwm[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) male calves in the first feeding period calculated on the basis of protein requirement

tdrypdiwm2[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) male calves in the second feeding period calculated on the basis of protein requirement

tdrys[i] Program EWBC: Predicted total dry matter intake per animal of category i ($i = 3, \ldots, CC$) in the summer feeding period

tdryse[i] Program EWBC: Predicted total dry matter intake per animal of category i ($i = 3, \ldots, CC$) in the summer feeding period calculated on the basis of energy requirement

tdryspdi[i] Program EWBC: Predicted total dry matter intake per animal of category i ($i = 3, \ldots, CC$) in the summer feeding period calculated on the basis of protein requirement

tdryt Program EWBC (only Production system 1): Predicted total dry matter intake of breeding bulls during performance test

tdrytb Program EWBC (only Production system 1): Predicted total dry matter intake of breeding bulls before performance test

tdrytbe Program EWBC (only Production system 1): Predicted total dry matter intake of breeding bulls before performance test calculated on the basis of energy requirement

tdrytbpdi Program EWBC (only Production system 1): Predicted total dry matter intake of breeding bulls before performance test calculated on the basis of protein requirement

tdryte Program EWBC (only Production system 1): Predicted total dry matter intake of breeding bulls during performance test calculated on the basis of energy requirement

tdrytpdi Program EWBC (only Production system 1): Predicted total dry matter intake of breeding bulls during performance test calculated on the basis of protein requirement

tdryts Program EWBC (only Production system 1): Predicted total dry matter intake of breeding bulls from the end of the performance test till selling

tdrytse Program EWBC (only Production system 1): Predicted total dry matter intake of breeding bulls from the end of the performance test till selling calculated on the basis of energy requirement

tdrytspdi Program EWBC (only Production system 1): Predicted total dry matter intake of breeding bulls from the end of the performance test till selling calculated on the basis of protein requirement

tdryw[i] Program EWBC: Predicted total dry matter intake per animal of category i ($i = 3, \ldots, CC$) in the winter feeding period

tdrywe[i] Program EWBC: Predicted total dry matter intake per animal of category i ($i = 3, \ldots, CC$) in the winter feeding period calculated on the basis of energy requirement

tdrywf[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves in the first feeding period

tdrywf2[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) female calves in the second feeding period

tdrywm[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) male calves in the first feeding period

tdrywm2[i] Program EWDC: Predicted total dry matter intake of pure-bred ($i = 0$) and cross-bred ($i = 1$) male calves in the second feeding period

tdrywpdi[i] Program EWBC: Predicted total dry matter intake per animal of category i ($i = 3, \ldots, CC$) in the winter feeding period calculated on the basis of protein requirement

tech1 Housing technology in fattening (1: free technology, 2: bind technology, 3: pasture, see Section 4.1.1.4)

tech2 Program EWDC: Housing technology in the cow herd (1: free technology, 2: bind technology, 3: pasture, see Section 4.1.1.4)

tha30[i] Program EWDC: Threshold values for curd firmness in the milk pricing system ($i = 0, ..., na30 - 1$)

thfat[i] Program EWDC: Threshold values for milk fat content in the milk pricing system ($i = 0, ..., nfat - 1$)

thprot[i] Program EWDC: Threshold values for milk protein content in the milk pricing system ($i = 0, ..., nprot - 1$)

thRCT[i] Program EWDC: Threshold values for rennet coagulation time in the milk pricing system ($i = 0, ..., nRCT - 1$)

to[i] Indicator for traits taking values 0, 1 or 2 ($i = 1, \ldots, NT - 1$).

- 0 Economic values or weights are never printed for these traits.
- 1 These traits are negatively selected in input file INPUT31.TXT (program EWDC) or INPUT34.TXT (program EWBC) or are omitted because of no fattening so that economic values of weights of these traits are not printed in the given calculation.
- 2 Economic values and weights are printed for these traits.

to3[i] Program EWDC: Indicator for traits from System 3 (EWBC) taking values 1 or 2 ($i = 43, 44, 47, 45$).

- 1 Economic values of weights of these traits are not printed in the given calculation if $to[i]$ has also the value 1. If $to[i] = 2$ the economic values are printed independent of the value of $to3[i]$.

2	Economic values and weights are printed for these traits.
totcal[i]	Program EWDC: Proportion of pure-bred ($i = 0$) and cross-bred ($i = 1$) calvings in the herd
Tprof	Total profit per cow entering the reproductive cycle (per cow and year)
Tprofh	Needed for the calculation of economic weights
Tprofl	Needed for the calculation of economic weights
Program	EWDC: Tprofm In the calculation of economic weights: keeps the value of the total profit $Tprof$
tr[i]	Length of the time period (in years) from calving to the time when the revenues in category i occur (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)
trait	Number of the trait (see Section A.2 on page 127)
Trev	Total revenues per cow entering the reproductive cycle (per cow and year)
tSCC[i]	Program EWDC: Upper limits for somatic cell count in milk quality class i ($i = 0, ..., nSCC - 2$) (the 1st class being the best one)
tSCS[i]	Program EWDC: Upper limits for somatic cell score in milk quality class i ($i = 0, ..., nSCC - 2$) (the 1st class being the best one)
TT	Dimension of quadratic matrix t[i][j], $TT = 6(LL - 1) + 4$
tt[i]	Type of trait: 0 for direct traits, 1 for maternal traits, 2 for traits with direct and maternal components; $i = 1, \ldots, NT - 1$
tvh, tvha, tvhb, tvhc, tvhd, tvhe	Needed for the calculation of economic weights
tvl, tvla, tvlb, tvlc, tvld, tvle	Needed for the calculation of economic weights
tvm, tvma, tvmb, tvmc, tvmd, tvme	Needed for the calculation of economic weights
u	Discount rate
utifemp	Program EWDC: Utilisation of pure-bred female calves which are not needed for replacement (1: selling of surplus reared female calves outside the systems, 2: fattening of surplus reared female calves, 3: selling of surplus breeding heifers before mating, 4: selling of surplus pregnant breeding heifers)
utifemcr	Program EWDC: Utilisation of cross-bred female calves (1: selling of reared calves outside the system, 2: fattening of reared calves, 3: selling [transferring] of cross-bred heifers to cow-calf Production System 3, 4: combination of fattening and selling of cross-bred female calves)
varmilk	Program EWDC: Variable costs per kg milk for increasing milk yield above average (labour, machine, cooling, energy etc.)
vetdys[j]	Veterinary cost connected with calving difficulty score j+1 ($j = 0, ..., DD-$ 1)
w1conf	Program EWBC: Weight of female calves at first weighing

w1conm Program EWBC: Weight of male calves at first weighing

w2conf Program EWBC: Weight of female calves at second weighing

w2conm Program EWBC: Weight of male calves at second weighing

w3conf Program EWBC: Weight of female calves at third weighing

w3conm Program EWBC: Weight of male calves at third weighing

wat[i] Daily amount of water per animal of category i (Program EWBC: $i = 1, ..., CC$, Program EWDC: $i = 1, ..., CT$)

wat10 Program EWDC: Amount of water per breeding bull per day

watwf[i] Program EWDC: Daily amount of water per female calf in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

watwm[i] Program EWDC: Daily amount of water per male calf in the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

wbbse Program EWBC: Weight of breeding bulls at purchase for natural mating

wbbst Program EWBC: Average weight of breeding bulls at the start of the performance test

wbbt Program EWBC: Average weight of breeding bulls at the end of the performance test

wbfat Program EWBC: Live weight of bulls at slaughter (at the end of fattening)

wbfat[i] Program EWDC: Live weight of bulls at slaughter (at the end of fattening; $i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

wbfatb Program EWDC: Live weight of pure-bred beef bulls at slaughter at the end of fattening

wcacal[i] Average weight of cows after calving in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

wcc[i] Average weight of cows culled within reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$) for health problems excluding dystocia

wccal[i] Average weight of cows at calving in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

wccw[i] Average weight of cows culled after calf weaning due to no pregnancy in reproductive cycle $i + 1$ ($i = 0, ..., LL - 1$)

wcd[i] Average weight of cows died within reproductive cycle i+1 ($i = 0, ..., LL-1$)

wcdys[i] Average weight of cows culled due to dystocia in reproductive cycle $i+1$ ($i = 0, ..., LL - 1$)

wcfat Program EWBC: Live weight of castrates at slaughter (at the end of fattening)

wcfat[i] Program EWDC: Live weight of castrates at slaughter (at the end of fattening; $i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

wcfatb Program EWDC: Live weight of beef castrates at slaughter (at the end of fattening)

wcwsc Program EWBC: Average weight of castrates culled in the period from weaning to the end of fattening before reaching the required slaughter weight

wcwsc[i] Program EWDC: Average weight of castrates culled in the period from the end of the rearing period to the end of fattening before reaching the required slaughter weight ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

wcwsf Program EWBC: Average weight of females culled in the period from weaning to the end of fattening before reaching the required slaughter weight

wcwsf[i] Program EWDC: Average weight of females culled in the period from the end of the rearing period to the end of fattening before reaching the required slaughter weight ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

wcwsm Program EWBC: Average weight of males culled in the period from weaning to the end of fattening before reaching the required slaughter weight

wcwsm[i] Program EWDC: Average weight of males culled in the period from the end of the rearing period to the end of fattening before reaching the required slaughter weight ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

wcxfat Program EWBC: Live weight of castrates at slaughter in extensive fattening

wcxs Program EWBC: Weight of castrates in extensive fattening at the end of the pasture period

wcxw Program EWBC: Weight of castrates in extensive fattening at the end of the winter period after weaning

wdcwf Program EWBC: Average weight of female calves died from 2 days of age to weaning

wdcwf[i] Program EWDC: Average weight of female calves died from 2 days of age to the end of the rearing period ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

wdcwm Program EWBC: Average weight of male calves died from 2 days of age to weaning

wdwsc Program EWBC: Average weight of castrates died in the period from weaning to the end of fattening

wdwsc[i] Program EWDC: Average weight of castrates died from the end of the rearing period to the end of fattening ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

wdwsf Program EWBC: Average weight of heifers died in the period from weaning to the end of fattening

wdwsf[i] Program EWDC: Average weight of heifers died from the end of the rearing period to the end of fattening ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

wdwsm Program EWBC: Average weight of bulls died in the period from weaning to the end of fattening

wdwsm[i] Program EWDC: Average weight of bulls died from the end of the rearing period to the end of fattening ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

wfrep Program EWBC: Weight of females for replacement at purchase

wfxs Program EWBC: Weight of heifers in extensive fattening at the end of the pasture period

wfxw Program EWBC: Weight of heifers in extensive fattening at the end of the winter period

wh1cal Program EWBC: Weight of heifers after the 1st calving for heifers conceived in their 1st mating period after their weaning. Program EWDC: Weight of heifers after their 1st calving

wh2cal Weight of heifers after their 1st calving for heifers mated in their 2nd mating period after weaning

wh3cal Weight of heifers after their 1st calving for heifers conceived in their 3rd mating period after weaning

whcal Weight of heifers after their 1st calving (average from heifers conceived in their 1st, 2nd and 3rd mating period after weaning)

whcmat Program EWBC: Average weight of heifers culled after the 1st, 2nd and 3rd mating periods after weaning because of no pregnancy. Program EWDC: Average weight of heifers culled after the maximal number of inseminations because of no pregnancy

whcmat1 Program EWBC: Average weight of heifers culled after the 1st mating period after their weaning because of no pregnancy

whcmat2 Program EWBC: Average weight of heifers culled after the 2nd mating period after their weaning because of no pregnancy

whcmat3 Program EWBC: Average weight of heifers culled after the 3rd mating period after their weaning because of no pregnancy

whdmh Average weight of heifers died in the rearing period

whfat Program EWBC: Live weight of heifers at slaughter (at the end of fattening)

whfat[i] Program EWDC: Live weight of heifers at slaughter (at the end of fattening; $i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

whfatb Program EWDC: Live weight of pure-bred beef heifers at slaughter at the end of fattening

whmat Program EWBC: Weight of heifers at mating averaged over all three mating periods

whmat1 Program EWBC: Average weight of heifers at mating for heifers mated in their 1st mating period after weaning

whmat1[i] Program EWDC: Average weight of heifers at their 1st insemination ($i = 0$: pure-bred animals, $i = 1$: cross-bred animals)

whmat2 Program EWBC: Average weight at mating for heifers mated in their 2nd mating period after weaning

whmat3 Program EWBC: Average weight at mating for heifers mated in their 3rd mating period after weaning

whmin Program EWBC: Minimal live weight of heifers for mating

whxfat Program EWBC: Live weight of heifers at slaughter in extensive fattening

wl_1[i] Program EWBC: Average amount of milk in kg produced during the winter period per cow in reproductive cycle 1 available for calves of category i ($i = 3, 8, 9$)

wl_2[i] Program EWBC: Average amount of milk in kg produced during the winter period per cow in reproductive cycle 2 available for calves of category i ($i = 3, 8, 9$)

wl_3[i] Program EWBC: Average amount of milk in kg produced during the winter period per cow in reproductive cycle 3 available for calves of category i ($i = 3, 8, 9$)

wl[i] Average amount of milk in kg produced during the winter period per cow (according to the age structure of the cows in the herd) available for calves of category i ($i = 3, 8, 9$)

wnphse Program EWBC: Weight of not-mated breeding heifers at selling

wphse Program EWBC: Weight of pregnant breeding heifers at selling

wpreg Weight gain in pregnancy = loss of cow weight after calving averaged over reproductive cycles 1 to LL

ws0[i] Program EWBC: Weight of animals of category i ($i = CC+1, \ldots, CC+10$) at the end of the "zeroth" summer feeding period[18] after their weaning

ws1[i] Program EWBC: Weight of animals of category i at the end of the 1st summer feeding period after their weaning

ws2[i] Program EWBC: Weight of animals of category i at the end of the 2nd summer feeding period after their weaning

ws3 Program EWBC: Weight of animals of category $CC + 6$ at the end of the 3rd summer feeding period after their weaning

ww[i] Program EWBC: Live weight of animals of category i ($i = 3, 8, 9, 25, ..., CC$) at the end of the winter feeding period, Program EWDC: Average live weight of animals of category i

ww1[i] Program EWBC: Weight of animals of category i at the end of the 1st winter feeding period after their weaning

[18] This period occurs only if calves are weaned before the end of the pasture period.

ww2[i] Program EWBC: Weight of animals of category i at the end of the 2nd winter feeding period after their weaning

ww3[i] Program EWBC: Weight of animals of category i at the end of the 3rd winter feeding period after their weaning

wwf Program EWBC: Weaning weight of female calves

wwf[i] Program EWDC: Weight of female calves at the end of the rearing period

wwm Program EWBC: Weaning weight of male calves

wwm[i] Program EWDC: Weight of male calves at the end of the rearing period

yacdi Program EWDC: Average claw disease incidence rate per cow and year (number of claw disease cases per cow and year averaged over all lactations). This variable includes only the cases which must be **treated with antibiotics** - compare *ynacdi*.

ymi Program EWDC: Average mastitis incidence rate per cow and year (number of clinical mastitis cases per cow and year averaged over all lactations)

ynacdi Program EWDC: Average claw disease incidence rate per cow and year (number of claw disease cases per cow and year averaged over all lactations). This variable includes only the cases which are **not treated with antibiotics** - compare *yacdi*.

zr Number of loop when calculating economic weights

zz Integer variable for numbering subsections in the output file TEXT_OUT.TXT (see Section 4.4)

zzdmi[i][j] Program EWDC: Needed for the calculation of economic weights (keeps the values of $dmi[i][j]$ during the calculation of the economic weight for mastitis incidence, of the same dimension as $dmi[i][j]$)

zzircmy[i] Program EWDC: Needed for the calculation of economic weights (keeps the values of $ircmy[i]$ during the calculation of the economic weight for mastitis incidence, of the same dimension as $ircmy[i]$)

zzlosc[i] Program EWDC: Needed for the calculation of economic weights, $i = 1, ..., 50$

zzmilksum[i] Program EWDC: Needed for the calculation of economic weights, keeps the original values of milksum[i]

Appendix B

Changes in the program EWBC since Version 1.0.22

B.1 Changes in May 2004

- Output file FROM1_3.TXT in Program EWBC was added (see Section 5.1.3 on page 120).

B.2 Changes in January 2005

- Special cases with zero trait values were taken into account when calculating the economic values (see Section 2.7.1).
- The option way of calculating feeding cost from the parameter file PARA.TXT (see Section 4.1.2) which was of no effect until recently will now work correctly.
- The economic values for the categorical traits 14 to 25 (see Numbering of traits, Appendix A.2 on page 127) will be calculated with the opposite sign as before. This change was made to put the printed values in agreement with the description of their calculation in Section 2.7.3 and to unify the calculation of economic weights. From now on, the economic weight will be always defined as the change in the total profit when increasing the trait value. Therefore the economic weights of traits where a decrease will be of a positive economic effect will have a negative sign.
- The input variable *dotcows* (Governmental subsidies per slaughter cow) was added in input file INPUT03.TXT.
- The new variable *ncows* (see Appendix A.3) was added.
- The profitability is newly calculated with and without subsidies and printed in the results file.
- The equation for the calculation of the average date of calving for cows in the herd (*davcalc*) was corrected. The change will be only of small impact on the results.
- The calculation of total cost for a breeding bull for natural mating in the herd from purchase to slaughter was corrected. The costs were decreased by the revenues from the slaughter animal.

- The variable *anphse* (average age of non-mated breeding heifers at selling) is not calculated in the program, but added as input parameter to the file INPUT13.TXT.
- The variable *aih* (heifers mated in their 1st oestrus as proportion of mated heifers) which was missing in input file INPUT14.TXT was added to this file.
- The variables *prrep*, *prnphse* and *prphse* (price of pregnant breeding heifers purchased for replacement, price of non-pregnant breeding heifers and price of pregnant breeding heifers at selling) which were defined per animal were redefined as prices per kg live weight.
- The variable *prbbcull* (price per kg carcass weight of old breeding bulls) was added to input file INPUT04.TXT.
- The variable *prbbsel* (price per breeding bull sold after test and selection) was added to input file INPUT05.TXT.
- The meaning of the variable *prbb* was changed to price per breeding bull purchased for natural mating (input file INPUT04.TXT).
- The variable $kmcwhmin = whmin/mcw$ was added in the program.
- Further cost components were calculated in the program and printed to the result file. These components are: *costcowy*, *costcw*, *costcwf*, *costcwm*, *costcwfkg*, *costcwmkg*, *costfatb*, *costfatbkg*, *costfatc*, *costfatckg*, *costfath*, *costfathkg*, *costhnpr*, *costhnprkg*, *costhpr*, *costhprkg*, *costvetc*, *costhc*, *costoc*, *costfixc*, *costfc*, *costc*. For their definition see List of variables in Appendix A.3.
- The calculation of the variables *avelifecc* and *avelifecy* was corrected. The meaning of the variable *avelifecc* was changed.

B.3 Changes in February 2005

- The variable *agehcal* which was the same as *agecal* was omitted and replaced by *agecal*.
- The number of reproductive cycles which was originally fixed to 10 is now variable and can be chosen by the user (values from 4 to 20 are allowed, low values might not work in several cases from the reason that there were not enough replacement heifers). The number of reproductive cycles (variable LL) was added as input parameter to the parameter file PARA.TXT. This had consequences for the dimension of vectors read from input files INPUT02.TXT and INPUT26.TXT. Several parameters in the program (T, C and G) are now the upper limit of the dimension of the appropriate vectors or matrices. The current values of these parameters (TT, CC and GG) are calculated from the current value of LL. The number of reproductive cycles was added as output parameter to the file FROM1_3.TXT.
- The expression of the economic values $ew0[i]$ was changed to be identical with the expression of the values $ew[i]$ (Originally, $ew[i]$ was expressed per change of the trait by 0.01 class or 10 g or 1%, whereas $ew0[i]$ was always expressed per unit of the trait, i.e. per class etc.). This has absolutely no consequences for the users of the program, as only the values $ew[i]$ are printed to the results file. All these values remained unchanged.

- An error in the calculation of gene flow was corrected. The error had only impact on Systems 2 and 3.

B.4 Changes from August to November 2005

- The input parameter *quota* was omitted from the parameter file PARA.TXT because this parameter is not used in the calculations.
- The units of the marginal economic values for traits 6 to 9 (average daily gain of calves from birth to 1st weighing, average daily gain of calves from the 1st to 2nd weighing, average daily gain of calves from the 2nd to 3rd weighing and average daily gain in the fattening period to constant slaughter weight) were changed from MU[1] per 10 g/d, cow and year to MU per g/d, cow and year.
- The marginal economic values for traits 14 to 17 (mean class of fleshiness for cows, bulls, heifers and castrates, respectively) and for traits 19 to 22 (mean class of fat covering for cows, bulls, heifers and castrates, respectively) are now expressed in the same way as the cumulative traits 18 and 23 (mean class of fleshiness or fat covering, respectively, for all categories together), e.g. per change of the mean class by 0.01.
- The marginal economic values for traits 24 and 25 (average score for calving performance for female or male calves, respectively) are now expressed in the same way as the cumulative trait 1 (average score for calving performance for male and female calves together), e.g. per change of the mean calving score by 0.01.
- The parameter NT was changed from 31 to its correct value 30 (number of traits increased by 1). This is of no consequence to the results, just unnecessary calculations are omitted.
- In all input files was the abbreviation Kc (Czech crowns) replaced by the more general term MU (monetary unit).
- Improvements in the text of all input files were made. This is of no effect to the program itself.

B.5 Changes from December 2008 to January 2009 (Version 2.1.1)

- The main change in the program is that calving is now possible at any time outside of the pasture period.
- The calculation of the variables *ndaycw* and *wh1cal* was modified.
- The last input in INPUT13.TXT (*anphse*) was replaced by four variables: *anphse*1, *anphse*2, *nphsold*1 and *nphsold*2. *anphse* will be calculated from these four variables in the program.
- In the program, two new variables (*aphse*1 and *aphse*2) were introduced.
- The structure of the output file CHECK was changed. All variables are now printed in only one alphabetic list.

[1] monetary unit

- The parameter "Utilisation of female calves which are not needed for replacement" ($utifem$) was found to be unnecessary and misleading and was therefore omitted from the program. This has no impact on the results.
- Five new variables were introduced: $adgs0[i]$, $ds0[i]$, $nes0[i]$, $pdis0[i]$ and $ws0[i]$ where i is the category of animals.

B.6 Changes from October 2009 to May 2010 (Version 2.1.3)

- A complete revision of the manual was carried out.
- Minor changes in the texts of the input files were made.
- The values of some variables which were printed as -0.00000 are now printed without the minus sign.
- The order of the input parameters in INPUT06.TXT was changed to be more logical.
- The variable "Mature body weight of bulls used in the herd" (mwb) was omitted in input file INPUT04.TXT as it is read already in INPUT06.TXT.
- The variables $adgs$, $kdysfc$ and $w[i]$ were dropped from the program as they were not needed in the calculations.
- The variable $dcost[i]$ (length of the period for which the costs are calculated for category i) was replaced by the variable $d[i]$ throughout the program because of duplicate definition.
- The variable $p[i]$ (vector of relative frequencies of the individual categories of progeny when the cow herd is in the stationary state) was replaced by the variable $l1[i]$ throughout the program because of duplicate definition.
- The calculation of $adgs2[CC+2]$, $adgw2[CC+2]$, $adgs2[CC+10]$, $adgw2[CC+10]$ and $dw3[CC+6]$ was corrected.
- The printout of the economic weights for direct and maternal trait components was unified between the programs EWBC and EWDC.

B.7 Changes from April 2011 to August 2011 (Version 2.2.1)

Besides of a basic revision of the program and the manual, the main news in this version are the calculation of relative economic weights and the introduction of a variable number of calving scores. In detail, the following changes and additions were made:

- Conceptions rate of cows (trait 13) should have only a maternal component and no direct component. This is now printed correctly in the results file.
- The following new variables were introduced: D, $delta\_d[i]$, $delta\_m[i]$, DD, $dotfatib$, $dyscl$, $ewr\_dd[i]$, $ewr\_da[i]$, $ewr\_mm[i]$, $ewr\_ma[i]$, $ewst\_d[i]$, $ewst\_m[i]$, $ewsum$, $ewsum\_d$, $ewsum\_m$, $flag[i]$, $gstd$, $gstd\_d[i]$, $gstd\_m[i]$, pbf, $pchf$, $to[i]$, $tt[i]$.

- A new option connected with the genetic standard deviations of traits was added to the parameter file PARA.TXT.
- The input file TEXT_OUT.TXT which is necessary for printing results was modified.
- Input files INPUT34.TXT, INPUT35.TXT and INPUT36.TXT were added.
- The original Table 4.1 was split into two tables (Table 4.1 on page 65 and Table 4.2 on page 88).
- In connection with the introduction of a variable number of calving scores, two new variables (*DD* and *dyscl*) were added at the beginning of input file INPUT02.TXT. All variables connected with calving score in input files INPUT02.TXT and INPUT03.TXT may now be read for up to six classes for calving score (the number of calving scores was fixed to 4 in the former version of the program).
- The maximal number of classes for fleshiness and fat covering was increased from 7 to 20.
- Technical changes were carried out in writing input data to results file. Until recently, the input files were more or less copied to the results file. Now this procedure is more selective. We tried to change the program in such a way that only input parameters which are needed for the calculation are printed in results. Also the part of printing economic values and economic weights is now more selective. For example, in Production System 3 where no heifers for replacement are produced the economic values and weights for traits expressed on cows and breeding heifers are omitted because the are of no importance for the selection of terminal sires. If these values will be needed for other purposes than selection of terminal sire, they can be found in file CHECKD (values of $ew[i][j]$).
- The output file FROM1_3.TXT is only written for Production System 3, as only data from Production System 3 will be needed in program EWDC.
- "Governmental support per fattened bull" was added as further input to INPUT08.TXT.
- The variable *daysc* was replaced by $d[19]$ and $d[20]$.
- The variable "Number of days from the average date of mating heifers to the date of culling barren heifers" (*dayshc*) was added to INPUT14.TXT.
- The variable *tconh* was omitted because of duplicate definition and replaced by *crh1mp*. This is of no effect on the calculations.
- The definition of traits 26 to 28 (see Appendix A.2) was corrected. Originally the traits were described as weight at different ages. However, the economic weights for these traits are calculated from average daily gain in three time intervals. Therefore these traits are more correctly to be defined as weight gain in three different time intervals.
- An error message was added when the date of calving is within the pasture period.

B.8 Changes from February to July 2012 (Version 2.3.1)

- Four new options connected with the calculation of economic values for residual dry matter intake were added to PARA.TXT.
- Four new traits were added (see Subsection 2.6.3):
  - Residual dry matter intake of heifers in rearing
  - Residual dry matter intake of animals in intensive fattening
  - Residual dry matter intake of animals in extensive fattening
  - Residual dry matter intake of adult animals (cows and breeding bulls)
- New inputs for residual dry matter intake were added to files INPUT03.TXT, INPUT04.TXT, INPUT05.TXT, INPUT08.TXT, INPUT09.TXT, INPUT10.TXT, INPUT13.TXT, INPUT14.TXT, INPUT35.TXT and INPUT36.TXT.
- The following new variables were introduced: $addry[i]$, $addrybbs$, $addrybbw$, $addryfas[i]$, $addrys[i]$, $addryt$, $addrytb$, $addrytse$, $addryw[i]$, $atdry[i]$, $atdrybbs$, $atdrybbw$, $atdryfas[i]$, $atdrys[i]$, $atdryt$, $atdrytb$, $atdrytse$, $atdryw[i]$, $ddry[i]$, $ddrybbs$, $ddrybbw$, $ddryfas[i]$, $ddrys[i]$, $ddryt$, $ddrytb$, $ddryts$, $ddryw[i]$, $rfi[i]$, rfi_cow, rfi_f, rfi_fa, rfi_fx, rfi_h, $rfis[i]$, $rfisc$, $rfisf$, $rfit$, $rfitb$, $rfits$, $rfiw[i]$, $tdry[i]$, $tdrybbs$, $tdrybbse$, $tdrybbspdi$ $tdrybbw$, $tdrybbwe$, $tdrybbwpdi$, $tdrye[i]$, $tdryfas[i]$, $tdryfase[i]$, $tdryfaspdi[i]$, $tdrypdi[i]$, $tdrys[i]$, $tdryse[i]$, $tdryspdi[i]$, $tdrytb$, $tdrytbe$, $tdrytbpdi$, $tdryts$, $tdrytse$, $tdrytspdi$, $tdryw[i]$, $tdrywe[i]$, $tdrywpdi[i]$. They are explained in Appendix A.3. Two variables were renamed: $ffww$ to $fw0$ and $pdibt$ to $pditb$.
- The variable $dw4$ was changed to the array $dw4[i]$.
- Some bugs in the calculation of net energy and protein requirement in the subcategories for breeding heifers (category 24) and for heifers for replacement selected before first mating and slaughtered (category 18) were corrected.
- The algoritm for the calculation of fresh feed matter requirement was changed. In the previous program version, fresh feed requirement was calculated in one step on the basis of dry matter, protein and energy content (or only dry matter and energy content) of all feeding rations for each animal category and each feeding period. Now, in the first step, the required total dry matter intake is calculated on the base of protein and energy (or only energy) content. In the second step, the predicted daily dry matter intake is calculated. In the third step, the daily residual dry matter intake is added to the predicted daily dry matter intake to get the actual daily dry matter intake. Next, the required fresh feed matter is calculated from the dry matter content. Finally, the fresh feed matter is increased by feed wasting.
- The file TEXT_OUT.TXT was changed. Information on residual dry matter intake was added. Total and daily dry matter intake are printed for several animal categories in the results file.
- The program was changed to allow the calculation of the economic value for Losses of calves at calving also in the case when all values in the following two vectors in INPUT02.TXT will be zero:
  - "Vector of calves died to 48 hours ...after dystocia ..." and

  - "Vector of calves died to 48 hours ...after easy calving ..."

- The text of Subsection 2.6.3 on page 37 was changed.
- The input file FROM1_3.TXT was changed - economic weights of more traits were added, some variables were moved to file T.TXT.
- If there is Production System 3, a new output file T.TXT (see Subsection 5.1.4 on page 120) is written which is needed in program EWDC.
- Text was added in the manual in Section 2.4 to explain the calculation of PDI.
- Typing errors in equations 2.15, 2.16 and 2.27 were corrected in the Manual. The equations were correctly programmed, no changes in the program were necessary.
- A bug in the program was corrected where the number of reproductive cycles was left fixed (as it was in the first version of the program).

Appendix C

Changes in the program EWDC since Version 1.0.18 (version 2.0.18 of the package ECOWEIGHT)

C.1 Changes in May 2006

- The part of the program concerning the calculation of the milk price was rewritten. For details see Section 2.5.1.2 which was also rewritten on the basis of the changes in the program. In the parameter file PARAD.TXT, the option for the calculation of the milk price was added (variable *milkprice*). The five options are explained in Paragraph 4.1.1.15.

- In the input file INPUT28.TXT, the new input parameter base milk price (*prmilkb*) was introduced. Several input parameters connected with somatic cell count or somatic cell score (mean of somatic cell score $mSCS$, phenotypic standard deviation of somatic cell score $sigmaSCS$, number of milk quality classes according to somatic cell content $nSCC$, upper limits for somatic cell count in the individual milk quality classes $tSCC[i]$) were moved from INPUT23.TXT to INPUT28.TXT.

- The input parameter "vector of base prices per kg milk in quality class i" ($prSCC[i]$) was moved from input file INPUT07.TXT to INPUT28.TXT.

- In input file INPUT11.TXT, a new input parameter (interval between two subsequent inseminations *inint*) was added.

- Two typing errors in equation (2.37) were corrected in the Manual.

C.2 Changes in January 2007

An error was detected in printing the economic weight for mastitis incidence. The program printed a value ten times greater than it should be. The error was corrected.

C.3 Changes in June and July 2007

- A new parameter "Crossing in the herd" was added to the parameter file PARAD.TXT.
- A bug was fixed were an array exceeded its limit.
- The calculation of some missing quantities for category $CC + 7$ was added.
- Changes were made in the algorithm for printing out the results in the results file. The output has become more selective omitting unnecessary data.
- The number of classes for calving performance which was fixed to 4 is now variable and can take values from 2 to 6.
- The structure of input file INPUT07.TXT was changed. The change concerns the last part of the file where input parameters for calving scores were sorted by the type of breeding - first the parameters for pure-breeding are given and then the parameters for crossbreeding are listed. The maximal number of calving scores has changed from 4 to 6. Leave all the lines in the input file, even if they are not read. The values for the classes of calving scores not occupied are just ignored.
- The structure of input file INPUT11.TXT was changed. At the beginning, the variable 'number of classes for calving performance' was added. Instead of four inputs for 'Veterinary cost connected with calving score x' and 'Stockman hours connected with calving score x' there are now six inputs.

C.4 Changes in October 2007

The aim of the changes carried out in October 2007 in the program EWDC was to include the option of selling male calves in the dairy system a few days after birth. Furthermore, the option of paying per live animal was added for calves and dystocia can be defined by the user.

- In input file INPUT21.TXT, several new parameters were included: price for female and male calves per animal (until recently, only paying per kg live weight was allowed), cost for removing and rendering dead calves.
- The definitions of the parameters $mxmc[i]$ and $mtest[i]$ were changed to "Proportion of male calves alive at 48 hours after birth that are determined for export (selling outside of the evaluated production system)" and "Proportion of male calves alive at 48 hours after birth that are sold as breeding males (e.g. to test stations or AI stations)". Both parameters are in input file INPUT15.TXT.
- In input file INPUT11.TXT, the new input parameter $dyscl$ was included. The parameter is the number of the lowest score for calving performance which is considered to be dystocia.
- In input file INPUT07.TXT, an additional comment was added which does in no way change the functionality of the file.
- The new option of selling male calves made it necessary to change the way the costs for categories 3 and $CC + 3$ were calculated; furthermore, the time when the costs for these categories occur had to be changed.
- The variables $Nmcw[i]$ and $wdcwm[i]$ were deleted in the program.

- The file TEXTD_OUT.TXT was changed to improve the output of results and to adopt it to the new features in the program.

C.5 Changes in November 2007

The maximal number of reproductive cycles which was originally fixed to 10 was made variable and can now be in the range from 4 to 15. Changing the number of reproductive cycles has consequences especially in input files INPUT07.TXT, INPUT27.TXT and INPUT29.TXT where care must be taken in all input parameters which depend on the number of reproductive cycles.

C.6 Changes in December 2007

- In input file INPUT21.TXT, the price of male breeding calves and breeding heifers which has been given either per kg live weight or per animal until recently may now be expressed both per kg live weight or per animal.
- In the file TEXTD_OUT.TXT in subsection 3.1. the reference unit "per cow and year" was corrected to "per cow and reproductive cycle".
- The variables $prnphse[i]$ and $prphse[i]$ were replaced by $pr[*]$ where $*$ stands for the corresponding categories of animals. Similarly, the variables $wnphse[j]$ and $wphse[j]$ were replaced by $ww[23+j\times CC]$ and $ww[24+j\times CC]$, $anphse[j]$ and $aphse[j]$ were replaced by $age[23+j\times CC]$ and $age[24+j\times CC]$. The variable $wwbse$ was changed to $ww[10]$ and $agebse[j]$ was changed to $age[10+j\times CC]$. All these changes are of absolutely no effect on the calculation, it's just a cleaning up of unnecessary variables.
- A new input file (INPUT12.TXT) was introduced. This input file is necessary in production systems where reared breeding male calves are kept to higher age at farms, that means stay at farms after the rearing period of calves till their selling to AI stations. As a consequence, the calculation of the costs for category 10 was generalised to include this situation.
- A bug in the calculation of costs for categories 23 and $23+CC$ was eliminated. A correction was made in calculation of costs for categories 3 and $3+CC$ which is only of negligible impact on the results.

C.7 Changes from March to May 2010 (Version 2.0.5)

- A complete revision of the manual was carried out.
- Minor changes in the texts of the input files were made.
- The option "production system" (*prodsys*) was omitted in PARAD.TXT because this parameter is fixed to 4 in EWDC.
- The option "way of calculating parameters for lactation curve" (*lactcur*) was omitted in PARAD.TXT because this parameter is not needed in EWDC.
- The variable "Genetic standard deviation for milk production" (*stdm*) was dropped from input file INPUT11.TXT and from the program as it is not needed in the calculations.
- A bug in the calculation of the average lifetime in years ($avelifecy$) was fixed.

- The printout of the economic weights for direct and maternal trait components was unified between the programs EWBC and EWDC.
- At the beginning of the parameter file a comment can now be inserted describing the calculation.

C.8 Changes from March to August 2011 (Version 2.1.2)

Besides of a basic revision of the program and the manual, the main news in this version are the addition of two traits connected with milk coagulation properties and two further traits and the calculation of relative economic weights. In detail, the following changes and additions were made:

- Conceptions rate of cows (trait 13) should have only a maternal component and no direct component. This is now printed correctly in the results file.
- Four further traits were introduced: rennet coagulation time, curd firmness, interval between 1st mating and calving in cows.
- The following new variables were introduced: $a30$, $cast[i]$, $delta\_d[i]$, $delta\_m[i]$, $ewr\_dd[i]$, $ewr\_da[i]$, $ewr\_mm[i]$, $ewr\_ma[i]$, $ewst\_d[i]$, $ewst\_m[i]$, $ewsum$, $ewsum\_d$, $ewsum\_m$, $flag[i]$, $gstd$, $gstd\_d[i]$, $gstd\_m[i]$, ind_a30, ind_RCT, $na30$, $nRCT$, $paf[i]$, $pbf[i]$, $pff[i]$, $prmilka30[i]$, $prmilkRCT[i]$, $ra30[i][j]$, RCT, $rRCT[i][j]$, $sigmaa30$, $sigmaRCT$, $tha30[i]$, $thRCT[i]$, $to[i]$, $tt[i]$. They are explained in Appendix A.3.
- Three new options connected with rennet coagulation time, curd firmness and genetic standard deviations of traits and two new options connected with fattening of castrates were added to the parameter file PARAD.TXT.
- Input file INPUT28.TXT was modified to include the potential impact of curd firmness and rennet coagulation time on the milk price. Therefore, rennet coagulation time and curd firmness were considered in the calculation of the milk price.
- The variables $NFAT$ and $NPROT$ were replaced by one variable ($NTHR$).
- Input data in the distributed version referring to monetary units are given in euros and not in Czech crowns as in the earlier versions.
- The input file TEXTD_OUT.TXT which is necessary for printing results was modified.
- Input files INPUT31.TXT, INPUT32.TXT and INPUT33.TXT were added.
- The original Table 4.1 was split into two tables (Table 4.1 on page 65 and Table 4.2 on page 88).
- The economic values or economic weights for traits which were unselected in INPUT31.TXT are no more printed in the results. Also, the economic value or economic weight for daily gain in fattening is not printed if there is no fattening in the system.
- Technical changes were carried out in writing input data to results file. The new procedure is more selective. We tried to change the program in such a way that only input parameters which are needed for the calculation are printed in results.

- The variable $p[j][i]$ (vector of relative frequencies of the individual categories of progeny when the cow herd is in the stationary state) was replaced by the variable $l1[i]$ throughout the program because of duplicate definition.
- The economic weight for cross-bred beef x dairy progeny for conception rate of cows ($ew[13][1]$) and average calving interval of cows ($ew[41][1]$) are no more calculated as there are no cross-bred beef x dairy cows in the system where these traits are expressed.
- An error in the calculation of the economic weights for maternal traits in systems with cross-breeding was corrected (the variable $ewwm[i][j]$ was not calculated correctly). This error had no impact on systems without cross-breeding.
- From technical reasons, input file INPUT15.TXT is now read first and the order of inputs in this file was changed. The following inputs were moved to the top of the file, otherwise the order remained the same:
  - Proportion of male calves alive at 48 hours after birth that are determined for selling outside of the evaluated production system
  - Proportion of male calves alive at 48 hours after birth that are sold as breeding males (e.g. to test stations or AI stations); here a change was carried out that only one value is read (for pure-bred progeny).
  - Castrates for fattening as proportion of male calves available for fattening
  - Cross-bred female calves sold expressed as proportion of surplus cross-bred female calves (moved from INPUT23.TXT).
- File INPUT25.TXT is not read if there is no fattening of cross-bred animals in the system.
- Several tests detecting potential inconsistencies among the parameters in file PARAD.TXT were added to the program.
- The definition of traits 26 to 28 (see Appendix A.2) was corrected. Originally the traits were described as weight at different ages. However, the economic weights for these traits are calculated from average daily gain in three time intervals. Therefore these traits are more correctly to be defined as weight gain in three different time intervals.

C.9 Changes from October to November 2011 (Version 2.2.1, not published on the Internet)

- Five new options connected with the calculation of economic values for claw diseases and residual dry matter intake were added to PARAD.TXT.
- Four new traits were added (see Subsection 2.6.3):
  - Incidence for claw disease (not yet considered in detail)
  - Residual dry matter intake of calves in rearing
  - Residual dry matter intake of heifers in rearing
  - Residual dry matter intake of animals in fattening
  - Residual dry matter intake of cows

- The economic values and weights for the four traits referring to dry matter intake are calculated (see Subsection 2.7.2).
- New inputs for residual dry matter intake were added to files INPUT11.TXT, INPUT12.TXT and INPUT21.TXT.
- The file TEXTD_OUT.TXT was changed. The most important changes were:
  - The actual total and actual daily dry matter intake were added for all categories and are now printed to the results file.
  - The numbers of categories for cross-bred progeny were given originally as fixed numbers. These were valid for models with 10 reproductive cycles (the number of reproductive cycles was originally fixed to 10). When changing to a variable number of reproductive cycles, we did forget to change these numbers. This error has been now corrected. The numbers of categories for cross-bred progeny are now given in the form "CC + number of the appropriate pure-bred category", where CC is calculated as 24 + number of cow categories which depends on the number of reproductive cycles. The value of CC is printed in the results file.
- The algoritm for the calculation of fresh feed matter requirement was changed. In the previous program version, fresh feed requirement was calculated in one step on the basis of dry matter, protein and energy content (or only dry matter and energy content) of all feeding rations for each animal category and each feeding period. Now, in the first step, the required total dry matter intake is calculated on the base of protein and energy (or only energy) content. In the second step, the predicted daily dry matter intake is calculated. In the third step, the daily residual dry matter intake is added to the predicted daily dry matter intake to get the actual daily dry matter intake. Next, the required fresh feed matter is calculated from the dry matter content. Finally, the fresh feed matter is increased by feed wasting.
- The following new variables were introduced: $claw\_inc$, $dc2[i]$, $ddry[i]$, $ddry2[i]$, $ddry10$, $ddrywf[i]$, $ddrywf2[i]$, $ddrywm[i]$, $ddrywm2[i]$, $rfi[i]$, $rfi2[i]$, $rfi10$, rfi_calf, rfi_cow, rfi_fa, $rfifc1[i]$, $rfifc2[i]$, rfi_h, $rfimc1[i]$, $rfimc2[i]$, $tdry[i]$, $tdry2[i]$, $tdry10$, $tdrye[i]$, $tdrye2[i]$, $tdrye10$, $tdryewf$, $tdryewf2$, $tdryewm$, $tdryewm2$, $tdrypdi[i]$, $tdrypdi2[i]$, $tdrypdi10$, $tdrypdiwf$, $tdrypdiwf2$, $tdrypdiwm$, $tdrypdiwm2$, $tdrywf$, $tdrywf2$, $tdrywm$, $tdrywm2$. They are explained in Appendix A.3.
- A new file with the name CHECKDhelp is now printed. This file contains the values of all variables before starting the calculation of economic weights. It is important for programming only and of no importance for the user. It helps just to test if the values of all variables which should be unchanged by the calculation of economic values are really unchanged.

C.10 Changes from February to July 2012 (Version 2.2.3)

- The program was changed to allow the calculation of the economic value for Losses of calves at calving also in the case when all values in the following two vectors in INPUT07.TXT will be zero:
  - "Vector of calves died to 48 hours ...after dystocia" and

  - "Vector of calves died to 48 hours ...after easy calving"

- Input files INPUT37.TXT and INPUT38.TXT were added which are connected with claw disease incidence.
- "Genetic standard deviation for claw disease incidence in the herd" and "Genetic standard deviation for residual dry matter intake in extensive fattening in System 3" were added as further inputs in the files INPUT32.TXT and INPUT33.TXT.
- The file TEXTD_OUT.TXT was changed.
- The economic value and weight for claw disease incidence is calculated.
- The following new variables were introduced: *costacd*, *costhcd*, *costnacd*, *costvetcd*, *discd*[*i*], *dismcd*, *ircdy*[*i*], *labherdcd*, *labvetcd*, *lossmcd*, *losstcd*, *pacd*[*i*], *prherdcd*, *prvetcd*, *sdcd*, *sdce*, *yacdi*, *ycdi*, *ynacdi*. They are explained in Appendix A.3.
- The trait "Residual dry matter intake in extensive fattening in System 3" was added.
- The input file FROM1_3.TXT was changed - economic weights of more traits were added and some variables were moved to file T.TXT.
- A new input file T.TXT was formed (see Subsection 5.1.4 on page 120).
- An error in the calculation of the number of cross-bred cows in System 3 expressed as proportion of dairy cows in System 4 (that means per dairy cow in System 4, variable *pc*) was corrected.
- Text was added in the manual in Section 2.4 to explain the calculation of PDI.
- Typing errors in equations 2.15, 2.16 and 2.27 were corrected in the Manual. The equations were correctly programmed, no changes in the program were necessary.
- In Subsection 2.4.2 a new equation for dairy calves was added and the corresponding equation in the program was changed.
- Three inputs in file INPUT31.TXT were omitted because they are needed only when there is a connection with Production System 3; in this case they are read from input file INPUT34.TXT of program EWBC and transferred to EWDC via file T.TXT.

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