Short User's Manual for the Program Package EWRAB (C Programs for Calculating Economic Weights for Rabbits), Version 2.0.1.

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Preface

The program EWRAB in the present version 2.0.1 allows for the calculation of the steady state of the doe population of the considered breed(s) or cross(es), for the calculation of the structure of progeny and for the calculation of variables connected with the growth of both purebred and crossbred progeny and with the nutrition of all animal categories. Furthermore, program calculates all costs and revenues, the profit in the whole production system and the marginal economic values and relative economic weights of traits in rabbits.

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[1] All variables used in equations in this manual are listed in alphabetic order in Appendix B.

[2] Purchasing young does is assumed only in Production system 3 and purchasing bucks for crossing using natural mating is assumed only in crossing systems, i.e in Production systems 2 and 3.

List of Tables

Abbreviations used in the text

AI	artificial insemination
BS	Production system
CW	carcass weight
d	day(s)
DE	digestible energy
DM	dry matter
EBW	empty body weight
EBG	empty body weight gain
kJ	kilo Joules
l	litre
LW	live weight
m^3	cubic metre(s) = 1000 litres
MJ	Mega Joules
mo.	month(s)
MU	monetary unit
NBA	Number of kits born alive
NE	net energy
NW	Number of kits weaned
TNB	Total number of kits born
yr	year(s)

Chapter 1

Introduction

The program EWRAB is an implementation of a bio-economic model of production systems of rabbits. This model is based on typical industrial rabbitry. Several production systems can be handled with the program EWRAB, purebred systems, purebred system with partial crossing and system with terminal crossing (see description of the systems below).

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

Chapter 2

Description of the production systems

The bio-economic model for rabbits can handle:

(1) Production system applying purebreeding which includes doe herds producing young does and bucks for own replacement (when natural mating is used) or bucks for AI stations (when AI is applied), and finishing surplus progeny for slaughter. Selling (exporting) of surplus female or male replacement is also possible.

(2) Production system applying crossbreeding for a part of doe herds (two-way crossing system). Bucks or sperm for crossing are purchased, but purebred doe and buck replacements are produced within the system. Surplus purebred and all crossbred progeny a finished. Selling (exporting) of surplus female or male replacement is also possible.

(3) Commercial production system buying crossbred doe replacements and bucks or their sperm for crossing (three-way crossing) and finishing all progeny.

The model is mostly deterministic and static; performances of animals are represented by their population means. The model is non-integer, that means, fractions of animals are allowed.

2.1 Management of the rabbit production systems

A typical industrial rabbitry, with multi-purpose cages for does and fattening animals and with replacement cages, was assumed for the bio-economic model.

Young replacement does are firstly mated (both natural mating and AI can be applied) at specified age and with target body weight. All does after kindling, which are not intended for culling due to bad mothering ability or health problems, are mated at the same day post-partum. The interval between parturition and mating appoints the length of doe reproductive cycles, because the length of pregnancy is fixed to 31 days. Does which did not conceive are culled or kept to the next reproductive cycle. Number of re-matings for non-pregnant does (i.e. number of reproductive cycle a non-pregnant doe is kept in the rabbitry) is assumed to be 1 in the model. Weaning of kits is made at fixed age. Kits not needed for replacement, or not intended for export as replacement, are fattened to target slaughter weight (selection and tagging of kits for replacement is assumed to be done short after kindling).

2.2 Structure of the doe herd

2.2.1 Definition of doe categories (doe states)

The structure of the doe population (doe herds) of a breed or crossbreed in the stationary state was calculated using a simple Markov chain model with culling probabilities as found empirically and not as a result of optimization. The procedure is similar to those described by Jalvingh et al. [2] or Reinsch and Dempfle [5] for cattle. Herd dynamics were described in terms of the states a doe can pass during her life (these states are called doe categories in the program) and the probabilities of possible transitions between them.

The doe categories (doe states) are related to each reproductive cycle of does that cover the interval between two subsequent kindlings (for does entering a reproductive cycles with kindlings). The maximal number of reproductive cycles is an input parameter (RR) which is expected to be in the range between 6 to 10. A replacement female enters the kindling group of does at her first kindling and stays in the herd until she is replaced or has reached the maximum number of reproductive cycles. **Notice that the maximum number of reproductive cycles includes also the "non-productive" cycle of does that did not conceived, but were kept in the herd. The number of kindlings of these does is then lower than the number of their reproductive cycles.**

Each doe category (doe state) is characterised by a combination of two state-variables: *reproductive-cycle-number (parity number)* i ($i = 1, ..., RR$) and *survival-class* j the doe is in within the given reproductive cycle.

The five survival classes of does within reproductive cycle i ($i = 1, ...RR - 1$) are defined as follows (the time, a doe in the given survival class is staying in the herd, is given in parentheses):

1 Does that died between kindling and kits weaning (from kindling to death)

2 Does culled after kit weaning for health problems or bad mothering ability without being mated (from kindling to culling)

3 Does culled for failure to conceive (from kindling to culling or from entering a reproductive cycle without kindling to culling)

4 Does not conceived but kept in the herd to the next reproductive cycle (whole kindling interval)

5 Does conceiving and completing the current reproductive cycle and beginning a new reproductive cycle at kindling (whole kindling interval)

In the last reproductive cycle ($i = RR$), only two survival-classes are defined:

1 Does that died between kindling and kits weaning (from kindling to death)

2 Barren does culled after kit weaning for age (from kindling to culling)

The total number of states (i.e. total number of doe categories) (TD) is therefore

$$TD = nstgD \times (RR - 1) + nstg1D = 5 \times (RR - 1) + 2 \; . \tag{2.1}$$

where $nstgD$ is the number of states a doe can pass in all but the last reproductive cycle and $nstg1D$ is the number of states a doe can pass in the last reproductive cycle.

There is a kindling at the beginning of each possible state except of does in state 4 that do not have kindling at the beginning of reproductive cycles 2 to $RR-1$. At the end of a state, the doe is either died (or culled), followed by a transition of the system to parity number one (i.e. replacement of the doe by a young doe) or, alternatively, kindling interval is completed and a transition of the system to the next parity number takes place (i.e. the same doe start a new parity with or without kindling). Because the died or culled does are not replaced immediately (a synchronisation of kindlings is assumed), the amount of time needed for a transition from one state to the next (the stage length) is the kindling interval.

The definition of the categories (states) of does is the first step on the way to the structure of the doe herd. In the next step, the probabilities of possible transitions between the doe categories (doe states) must be calculated which are the elements $td[i][j]$ of the transition matrix $\mathbf{T_D}$.

2.2.2 Building of the transition matrix $\mathbf{T_D}$

To fill the elements of the matrix, the values of several variables will be needed first.

2.2.2.1 Calculation of several variables[1] needed for transition matrix $\mathbf{T_D}$

- Does culled in reproductive cycle i ($i = 1, \ldots, RR-1$) after kit weaning for health problems or low litter size without being mated as proportion of does starting cycle i or does culled after kit weaning for age in the last cycle $i = RR$, also as proportion of does starting this cycle ($pcwfD[i]$):

$$pcwfD[i] = \begin{cases} (1 - pdfwD[i]) \times pcwD[i] & \text{for } i = 1, \ldots, RR-1 \\ 1 - pdfwD[i] & \text{for } i = RR \end{cases} \tag{2.2}$$

- Does mated in reproductive cycle i ($i = 1, \ldots, RR-1$) expressed as fraction of does entered cycle i ($pmatD[i]$):

$$pmatD[i] = 1 - pdfwD[i] - pcwfD[i] \tag{2.3}$$

- Does pregnant after mating in reproductive cycle i ($i = 1, \ldots, RR-1$) expressed as fraction of does entering cycle i ($pconD[i][j]$):

$$pconD[i] = pmatD[i] \times conrateD[i] \tag{2.4}$$

- Does culled in reproductive cycle i ($i = 1, \ldots, RR-1$) for failure to conceive expressed as fraction of does entered cycle i ($pcullD[i]$):

$$pcullD[i] = (pmatD[i] - pconD[i]) \times (1 - pbarrD[i]) \tag{2.5}$$

- Does not pregnant in reproductive cycle i ($i = 1, \ldots, RR-1$), but kept to the next reproductive cycle expressed as fraction of does entered cycle i ($pstayD[i]$):

$$pstayD[i] = (pmatD[i] - pconD[i]) \times pbarrD[i] \tag{2.6}$$

- Does entering the next reproductive cycle $i+1$ with and without kindling expressed as fraction of does entered cycle i ($pconstayD[i]$):

$$pconstayD[i] = pconD[i] + pstayD[i] \tag{2.7}$$

[1] All variables used in equations in this manual are listed in alphabetic order in Appendix B.

2.2.2.2 Calculation of the elements of the transition matrix

We write $td[i][j]$ for the elements of the transition matrix $\mathbf{T_D}$, i being the index for the row and j being the index for the column. For the first five ($= nstgD$) columns, the non-zero elements are:

$$\begin{aligned} td[i][1] &= pdfwD[1] \\ td[i][2] &= pcwfD[1] \\ td[i][3] &= pcullD[1] \\ td[i][4] &= pstayD[1] \\ td[i][5] &= pconD[1] \end{aligned} \tag{2.8}$$

where $i = nstgD \times j + k = 5 \times j + k$ with $j = 0, \ldots, RR - 1$ and

$$k = \begin{cases} 1, \ldots, 3 & \text{for } j = 0, \ldots, RR - 2 \\ 1, 2 & \text{for } j = RR - 1 \end{cases} . \tag{2.9}$$

For the columns greater than $nstgD = 5$, we get for the non-zero elements of the matrix

$$\begin{aligned} td[i][nstgD \times j + 1] &= pdfwD[j + 1] \\ td[i][nstgD \times j + 2] &= pcwfD[j + 1] \\ td[i][nstgD \times j + 3] &= pcullD[j + 1] \\ td[i][nstgD \times j + 4] &= pstayD[j + 1] \qquad (2.10) \\ td[i][nstgD \times j + 5] &= pconD[j + 1] \qquad (2.11) \end{aligned}$$

where $i = nstgD \times (j - 1) + k = 5 \times (j - 1) + k$ with $k = 4, 5$ and $j = 1, \ldots, RR - 1$ for the first two equations and $j = 1, \ldots, RR - 2$ for the last three equation.

The sum of elements in each row of the transmission matrix must be 1. The program checks if this condition is fulfilled. If the condition is not fulfilled the program reports an error.

2.2.3 Calculation of the steady state of the doe herds

The transition probabilities, which are the elements of the transition matrix $\mathbf{T_D}$, are calculated using information about conception, culling and mortality rates of does at different parities (see Paragraph 2.2.2.2).

Let $\mathbf{T_D}$ be the quadratic transition matrix of dimension TD with elements $td[i][j]$ where $td[i][j]$ is 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, i.e. the kindling interval). 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:

$$\mathbf{c}^{[t+\Delta t]} = \mathbf{c}^{[t]}\mathbf{T_D} . \tag{2.12}$$

For $t \to \infty$, the Markov chain reaches its steady state; that means the difference $\mathbf{c^{[t+\Delta t]}} - \mathbf{c^{[t]}}$, converges to zero. In the program, the steady state is calculated by an iteration procedure. The initial value for $\mathbf{c^{[t]}}$ at start time t_0 is:

$$\mathbf{c}^{[t_0]} = \begin{bmatrix} 1 & 0 & \ldots & 0 \end{bmatrix} . \tag{2.13}$$

For more details see also [12] where the steady state of a cow herd was calculated.

2.2.4 Calculation of some further quantities for doe herd and young replacement does

In the following text, we will write $l1D[i]$ for the elements of vector $\mathbf{c}^{[\mathbf{t}]}$ from equation (2.12) for $t \to \infty$. $l1D[i]$ $(i = 1, \ldots, TD)$ is the proportion of does of the i^{th} category and $\sum_{i=1}^{TD} l1D[i] = 1$. The number of does entered the reproductive cycle (i.e. parity) i $(i = 1, \ldots, RR)$ expressed as proportion of does entered any parity $(l2D[i])$ is calculated as follows:

$$l2D[i] = \begin{cases} \sum_{j=1}^{5} l1D[(i-1) \times 5 + j] & \text{for } i = 1, \ldots, RR-1 \\ \sum_{j=1}^{2} l1D[(i-1) \times 5 + j] & \text{for } i = RR \end{cases} . \tag{2.14}$$

It holds that $\sum_{i=1}^{RR} l2D[i] = 1$.

The number of does that had kindling at beginning of the reproductive cycle (i.e. parity) i $(i = 1, \ldots, RR)$ expressed as proportion of does entered any parity $(l3D[i])$ is calculated as follows:

$$l3D[i] = \begin{cases} l2D[i] & \text{for } i = 1 \\ l1D[(i-1) \times 5] & \text{for } i = 2, \ldots, RR \end{cases} . \tag{2.15}$$

It holds that $\sum_{i=1}^{RR} l3D[i] <= 1$

Number of does entered reproductive cycle i $(i = 1, \ldots, RR)$ without kindling $(l4D[i])$ as proportion of does entered any reproductive cycle is:

$$l4D[i] = l2D[i] - l3D[i] . \tag{2.16}$$

It holds that $\sum_{i=1}^{RR} l4D[i] < 1$ and it holds that $\sum_{i=1}^{RR}(l3D[i] + l4D[i]) = 1$.

Number of young does pregnant (after the first and second mating) as proportion of young does firstly mated $connyD$ is:

$$connyD = con1G + (1 - con1G) \times pbarrG \times con2G . \tag{2.17}$$

Number of young does that must be firstly mated per doe $(nmat1G)$ and per reproductive cycle is:

$$nmat1G = \frac{l2D[1]}{connyD} . \tag{2.18}$$

Number of young does mated for the second time $(nmat2G)$ per doe per reproductive cycle is

$$nmat2G = nmat1G \times (1 - con1G) \times pbarrG . \tag{2.19}$$

The total number of matings (insemination) per doe per reproductive cycle including matings of young replacement does (inD) is calculated as:

$$inD = \sum_{i=1}^{RR-1} pmatD[i] \times l2D[i] + nmat1G + nmat2G . \tag{2.20}$$

.

The total number of crossbred matings (insemination) per doe per reproductive cycle including crossbred matings of young replacement does $(incrossD)$ is calculated only for Production system 2 as:

$$\begin{aligned} incrossD \quad = \quad & \sum_{i=1}^{RR-1} (pmatD[i] \times l2D[i] \times pcrossD[i]) \\ & + (nmat1G + nmat2G) \times pcrossD[0] . \end{aligned} \tag{2.21}$$

The total number of purebred matings (insemination) per doe per reproductive cycle including purebred matings of young replacement does ($inpurD$) is calculated as:

$$\begin{aligned} inpurD &= \sum_{i=1}^{RR-1} (pmatD[i] \times l2D[i] \times (1 - pcrossD[i])) \\ &\quad + (nmat1G + nmat2G) \times (1 - pcrossD[0]) \ . \end{aligned} \tag{2.22}$$

Females (young and mature does) mated with bucks of a different breed as proportion of all mated females ($pcrosst$) is calculated as

$$pcrosst = \frac{incrossD}{incrossD + inpurD} \ . \tag{2.23}$$

Females (young and mature does) mated with bucks of the same breed as proportion of all mated females ($ppurt$) are calculated as

$$ppurt = 1 - pcrosst \ . \tag{2.24}$$

.

The number of young does that must be reared after weaning for own herd replacement (not including young does exported as breeding animals outside the breeding system) per doe per reproductive cycle ($nurreplG$) is[2]:

$$nurreplG = \frac{nmat1G}{1 - pdiedG} \ . \tag{2.25}$$

The survival rate of young does during rearing (srG, in %) is:

$$srG = 100 \times (1 - pdiedG) \ . \tag{2.26}$$

The doe conception rate averaged over all reproductive cycles ($conrateD0$) is:

$$conrateD0 = \frac{\sum_{i=1}^{RR-1} conrateD[i] \times l2D[i] \times pmatD[i]}{\sum_{i=1}^{RR-1} l2D[i] \times pmatD[i]} \ . \tag{2.27}$$

The following variables are connected with doe productive lifetime and kindling interval.

The length of doe reproductive cycles (i.e. the kindling interval, $fintD$) is calculated as:

$$fintD = intkm + lpreg \ , \tag{2.28}$$

where $intkm$ is interval between kindling and mating and $lpreg$ is the length of pregnancy (31 days).

The time (in days) a doe category i ($i = 1, \ldots, TD$) is defined for ($d[i]$) is calculated as[3]:

$$d[i] = \begin{cases} agew/2 & \text{for } i = 1 + 5 \times (j-1) \\ agew & \text{for } i = 2 + 5 \times (j-1) \end{cases} \tag{2.29}$$

[2]The variable ($nurreplG$) is not calculated in the program run for Production system 3 with crossbred does.

[3]For simplicity, it is assumed that does died in average in the middle of the period kindling - weaning

where $j = 1, \ldots, RR$ and

$$d[i] = \begin{cases} intkm + inmcD & \text{for } i = 3 + 5 \times (j-1) \\ fintD & \text{for } i = 4 + 5 \times (j-1) \\ fintD & \text{for } i = 5 + 5 \times (j-1) \end{cases} \tag{2.30}$$

where $j = 1, \ldots, RR - 1$.

The average productive lifetime of does of category i ($pltD[i]$, $i = 1, \ldots, TD$), i.e. the time from the first kindling to culling or death (in days), is calculated as

$$pltD[i] = d[i] + \sum_{j=0}^{\text{int}(i/5.0-0.1)} d[5 \times j] \tag{2.31}$$

where $d[0] = 0.0$ is formally assumed for the non-existing category 0 and $\text{int}(i/5.0 - 0.1)$ calculates the number of the reproductive cycle diminished by 1 to which the doe category belongs. The last term in that equation is simply the sum of kindlings intervals from the first until the last farrowing of the does in the given category. The productive lifetime of does in days averaged over all doe categories ($pltdD$) is then

$$pltdD = \sum_{i=1}^{TD} pltD[i] \times l1D[i] \tag{2.32}$$

and the productive lifetime of does in years averaged over all doe categories ($pltyD$) is

$$pltyD = pltdD/365.25 \ . \tag{2.33}$$

The average productive lifetime of does expressed in number of reproductive cycles ($pltnfD$) is

$$pltnfD = \frac{1}{l2D[1]} \ . \tag{2.34}$$

The number of kindlings per doe ($nkind$)in the herd is then:

$$nkind = \sum_{i=1}^{RR} l3D[i] \ . \tag{2.35}$$

It holds that $nkind <= 1$. Number of does entered a reproductive cycle without kindling (npD) per doe in the herd is:

$$npD = 1 - nkind \ . \tag{2.36}$$

In the following text, some quantities will be calculated which are connected with doe replacement. The mortality rate of does averaged over all reproductive cycles ($pdiedD0$) is calculated as

$$pdiedD0 = \sum_{i=1}^{RR} l2D[i] \times pdfwD[i] \ . \tag{2.37}$$

Culling rate for health or bad mothering ability after weaning averaged over all reproductive cycles ($pcwfD0$) is calculated as

$$pcwfD0 = \sum_{i=1}^{RR-1} l2D[i] \times pcwfD[i] \ . \tag{2.38}$$

Culling rate for failure to conceive averaged over all reproductive cycles ($pcullD0$) is calculated as

$$pcullD0 = \sum_{i=1}^{RR-1} l2D[i] \times pcullD[i] \ . \tag{2.39}$$

Culling rate for age is

$$pcageD0 = (1 - pdfwD[RR]) \times l2D[RR] \ . \tag{2.40}$$

Does died ($pdiedDp$), involuntary culled for health problems or bad mothering ability ($pcwfDp$), involuntary culled for failure to conceive ($pcullDp$) during any reproductive cycle and does culled for age in the last reproductive cycle ($pcageDp$), each expressed as percentage of does replaced are calculated as:

$$\begin{aligned} pdiedDp &= 100 \times \frac{pdiedD0}{l2D[1]} \\ pcwfDp &= 100 \times \frac{pcwfD0}{l2D[1]} \\ pcullDp &= 100 \times \frac{pcullD0}{l2D[1]} \\ pcageDp &= 100 \times \frac{pcageD0}{l2D[1]} \ . \end{aligned} \tag{2.41}$$

The average annual replacement rate ($arrDp$) of does (%) is given as:

$$arrDp = 100 \times \frac{365.25 \times l2D[1]}{fintD} \ . \tag{2.42}$$

2.3 Calculation of parameters connected with breeding bucks

The number of bucks which must be reared per doe in a production system or which must be purchased for crossing depends after all on the type of mating ($mtype[j]$, input parameter in INPUTR04.TXT), on the proportion of does in the herd mated with bucks of the same (pure-breeding, $j = 0$) and of different genotypes (cross-breeding $j = 1$) and on the reproductive ability of the bucks. When running the program for a certain production system, two types of bucks may be differentiated: bucks of the same breed as the breed of the does and bucks of a breed or cross different from the breed of the does. If variables refer to both types of bucks, index 0 is used for bucks of the first type and index 1 is used for bucks of the second type. Variables with index 1 are calculated only if there is crossing. In the program run for the crossbred does (Production system 3), calculations are carried out only for bucks different from the genotype of the does. It is assumed that bucks used for purebreeding, whether sold to AI station for sperm production or included in the herd for natural mating, are reared within the evaluated breeding system.

Mating type ($mtype[j]$ where $j = 1, 2$) is coded in the following way:

- 1: Artificial insemination (AI) is used throughout
- 2: Natural mating is used throughout

For both mating type, the following variables are calculated:

- The survival rate (%) of bucks of genotype $j = 0$: (bucks of the same breed as the breed of the does in rearing is (calculated only in Production systems 1 and 2):

$$srB[0] = 100 \times (1 - pdiedB[0]) \ . \tag{2.43}$$

- The number of purebred matings for buck of the same genotype as does ($nmatB[0]$) and number of crossbred matings for bucks of genotype different from those of does ($nmatB[1]$) per doe and reproductive cycle including mating of young replacement does is:

$$\begin{aligned} nmatB[0] &= inpurD \\ nmatB[1] &= incrossD \ . \end{aligned} \tag{2.44}$$

2.3.1 Calculations for mating type 1 (artificial insemination)

- Number of sperm doses from bucks of genotype $j = 0$, used for purebreeding (if bsyst<3), and of genotype $j = 1$, used for crossbreeding (if bsyst>1), needed per doe and per reproductive cycle including sperm doses for young replacement does ($nAID[j]$) is:

$$nAID[j] = nmatB[j] \tag{2.45}$$

The following variables are calculated only for bucks of genotype $j = 0$ (i.e. of the same genotype as the doe genotype).

- Average productive lifetime of bucks used for sperm production on AI stations ($lifespcyB[0]$), expressed in doe reproductive cycles is calculated as:

$$lifespcyB[0] = \frac{lifespB[0]}{fintD} \tag{2.46}$$

- Number of young bucks (of an age about 18 to 22 weeks) used for sperm production as proportion of all bucks of the same genotype used for sperm production ($pspyB[0]$):

$$pspyB[0] = \frac{1}{lifespcyB[0]} \tag{2.47}$$

- Overall number of bucks (both young and mature bucks) needed for sperm production per doe per reproductive cycle ($numspB[0]$):

$$numspB[0] = \frac{nmatB[0]}{spermoB[0] \times (1 - pspyB[0]) + spermyB[0] \times pspyB[0]} \tag{2.48}$$

- Number of young bucks that must be sold to AI stations per doe and per reproductive cycle ($numspyB[0]$):

$$numspyB[0] = \frac{numspB[0] \times pspyB[0]}{pcullB[0]} \tag{2.49}$$

2.3.2 Calculations for mating type 2 (natural mating)

The following calculations are done for bucks of genotype $j = 0$ (bucks of the same genotype as doe genotype in the case when the Production system $bsyst < 3$) and for bucks of genotype $j = 1$ (bucks of genotype different from doe genotype in the caste when the Production system $bsyst > 1$).

- Average productive lifetime of bucks of genotype $j = 0, 1$ used for natural mating expressed in number of doe reproductive cycles ($lifenmcyB[j]$):

$$lifenmcyB[j] = \frac{lifenmB[j]}{fintD} \tag{2.50}$$

- Number of young bucks of genotype $j = 0, 1$ as proportion of all bucks of the same genotype used for natural mating ($pnmyB[j]$):

$$pnmyB[j] = \frac{1}{lifenmcyB[j]} \tag{2.51}$$

- The number of bucks (both young and mature bucks) of genotype $j = 0, 1$ needed for natural mating per doe per reproductive cycle ($numnmB[j]$) is calculated as:

$$numnmB[j] = \frac{nmatB[j]}{doeoB[j] \times (1 - pnmyB[j]) + doeyB[j] \times pnmyB[j]} \tag{2.52}$$

- The number of young bucks of genotype $j = 0, 1$ that must be included in the herds for natural mating per doe and per reproductive cycle ($numnmyB[j]$), is then calculated as:

$$numnmyB[j] = \frac{numnmB[j] \times pnmyB[j]}{pcullB[j]} \tag{2.53}$$

2.3.3 Calculations for both mating types

The following variables are calculated only for bucks of genotype $j = 0$ (i.e. of the same genotype as the doe genotype).

- Total number of young bucks of genotype $j = 0$ that must be reared until the age at which bucks are used for 1st mating or sperm collection (for sperm production or for natural mating) per doe per reproductive cycle ($numyB[0]$):

$$numyB[0] = \begin{cases} numspyB[0] & \text{for } mtype[j] = 1 \\ numnmyB[0] & \text{for } mtype[j] = 2 \end{cases} \tag{2.54}$$

- Number of male kits of genotype $j = 0$ that must be reared after weaning as replacement bucks used for sperm production or for natural mating per doe and per reproductive cycle ($nurreplB[0]$):

$$nurreplB[0] = \frac{numyB[0]}{1 - pdiedB[0]]} \tag{2.55}$$

2.4 Structure of own progeny and purchased does or bucks[4]

The term "progeny" as it is used in the present manual refers either to progeny of the does in the considered production system (breed) or to purchased young animals from other farms (when applying crossbreeding).

[4] Purchasing young does is assumed only in Production system 3 and purchasing bucks for crossing using natural mating is assumed only in crossing systems, i.e in Production systems 2 and 3.

2.4.1 Categories of progeny

Categories of progeny are formed in accordance with the phases in rabbit production, i.e. kits till weaning, rearing of female and male replacement, fattened animals are distinguished. The sex ratio of weaned kits is an input parameter in input file INPUTR03.TXT (see Section 7.1.4). The frequency of stillborn kits, mortality rates till weaning and in fattening are not distinguished between sexes. Each progeny can be of two breeding types (genotypes), purebred ($j = 0$) or crossbred ($j = 1$). In Production system 3, the purchased doe replacements have also index $j = 0$, because they have the same genotype as does. That means, the word "purebred" is generally used for progeny and young replacements their genotype is the same as the genotype of does. Some categories of progeny are missing in specific breeding systems (e.g. in purebred systems, only purebred categories exist). The following progeny categories are defined (the time in which the category exists is given in parentheses; the number of the category is identical to index i ($i = 1, \ldots, ...16$) in $l1P[i][j]$, see Subsection 2.4.2 on the following page):

1. Stillborn kits (0)
2. Kits died from birth till weaning (birth to death)
3. Kits survived from birth until weaning at fixed age (birth to weaning)
4. Animals died during fattening (from weaning to death)
5. Animals finished to target slaughter weight (from weaning to slaughter)
6. Doe replacements died during the rearing phase (from weaning to death)
7. Young breeding does sold (exported) (from weaning to selling)
8. Doe replacements reared within the system and firstly mated (from weaning to first mating) or young crossbred doe replacement purchased before mating and firstly mated [5] (from purchase to first mating)
9. Doe replacements (own reared progeny or purchased crossbred does) not conceived after 1st mating, but kept in the herd and mated for the 2nd time in the next mating cycle (from 1st to 2nd mating)
10. Doe replacements mated (own reared progeny or purchased crossbred does), but not conceived and culled (from 1st mating and from 2nd mating to culling)[6]
11. Doe replacements (own reared progeny or purchased crossbred does) mated one or twice and have kindling (from mating[7] to 1st kindling)
12. Buck replacements reared for natural mating or for sperm production on AI stations, but died during the rearing phase (from weaning to death)
13. Buck replacements reared for natural mating in the rabbitry (from weaning to culling) or young replacement bucks of genotype different from doe genotype

[5] Only in Production system 3 with crossbred does. It is assumed that young does are purchased before mating, the age and weight of these replacement at purchase are input parameters in Production system 3

[6] Both matings, the 1st and if exists also the 2nd mating are taken into account defining this category. The starting weight and age and the age at first kindling is calculated as a weighted average from weights or ages of replacements mated ones and those mated twice.

[7] See footnote 6

purchased for crossing using natural mating (0)[8], but culled for unsuitability for mating

14. Buck replacements reared in the rabbitry and used for purebreeding applying natural mating (from weaning to their first used for mating) or young replacement bucks of genotype different from doe genotype purchased and used for crossing applying natural mating (0)[9]

15. Buck replacements sold to insemination stations (from weaning to selling)

16. Young breeding bucks sold (exported) (weaning to selling)

2.4.2 Calculation of the array l1P

The structure of progeny is described by the array **l1P** with elements $l1P[i][j]$, where i is the category of progeny and j is the genotype of progeny. $l1P[i][j]$ is the number of animals of category i and genotype j per doe (entered any reproductive cycle with or without kindling) averaged over all reproductive cycle (i.e. per interval between kindlings). The elements with index $j = 0$ are calculated in Production systems 1 and 2 (i.e. if the variable $bsyst < 3$), the elements with index $j = 1$ are calculated in Production systems 2 and 3 in which crossbreeding is applied (i.e. if the variable $bsyst > 1$).

2.4.2.1 Averaging litter size traits over parities and over genotypes within parities

In all following equations $pcrossD[0]$ means the proportion of crossing of the young replacement does.

- Average total number of purebred ($nbt[0]$) or crossbred ($nbt[1]$) kits born per doe and per reproductive cycle[10]:

$$\begin{aligned} nbt[0] &= \sum_{i=1}^{RR} nb[i][0] \times l3D[i] \times (1 - pcrossD[i-1]) \\ nbt[1] &= \sum_{i=1}^{RR} nb[i][1] \times l3D[i] \times pcrossD[i-1] \end{aligned} \tag{2.56}$$

- Average number of purebred ($nbat[0]$) or crossbred ($nbat[1]$) kits born alive per doe and per reproductive cycle:

$$\begin{aligned} nbat[0] &= \sum_{i=1}^{RR} nba[i][0] \times l3D[i] \times (1 - pcrossD[i-1]) \\ nbat[1] &= \sum_{i=1}^{RR} nba[i][1] \times l3D[i] \times pcrossD[i-1] \end{aligned} \tag{2.57}$$

[8] Only in Production systems 2 and 3. It is assumed that young bucks for crossing are purchased shortly before mating and animals unsuitable for mating are culled shortly after purchasing, therefore the time period for this category is zero.

[9] Only in Production systems 2 and 3. It is assumed that young bucks are purchased shortly before mating, therefore, the time period for this category is zero.

[10] Does with and without kindling are included

- Average number of purebred ($nwt[0]$) or crossbred ($nwt[1]$) kits weaned per doe and per reproductive cycle:

$$\begin{aligned} nwt[0] &= \sum_{i=1}^{RR} nw[i][0] \times l3D[i] \times (1 - pcrossD[i-1]) \\ nwt[1] &= \sum_{i=1}^{RR} nw[i][1] \times l3D[i] \times pcrossD[i-1] \end{aligned} \tag{2.58}$$

- Total number of kits born per kindling in the i^{th} parity ($i = 1, \ldots, RR$) averaged over purebred and crossbred litters ($nb0[i]$):

$$nb0[i] = nb[i][0] \times (1 - pcrossD[i-1]) + nb[i][1] \times pcrossD[i-1] \tag{2.59}$$

- Number of kits born alive per kindling in the i^{th} parity ($i = 1, \ldots, RR$) averaged over purebred and crossbred litters ($nba0[i]$):

$$nba0[i] = nba[i][0] \times (1 - pcrossD[i-1]) + nba[i][1] \times pcrossD[i-1] \tag{2.60}$$

- Number of kits weaned per kindling in the i^{th} parity ($i = 1, \ldots, RR$) averaged over purebred and crossbred litters ($nw0[i]$):

$$nw0[i] = nw[i][0] \times (1 - pcrossD[i-1]) + nw[i][1] \times pcrossD[i-1] \tag{2.61}$$

2.4.2.2 Survival and mortality rates of kits in different periods

- Percentage of stillborn kits of genotype j ($j = 0$, purebred progeny, calculated if $bsyst < 3$, $j = 1$ crossbred progeny, calculated if $bsyst > 1$) averaged over doe reproductive cycles ($pstill[j]$):

$$pstill[j] = 100 \times \frac{nbt[j] - nbat[j]}{nbt[j]} \tag{2.62}$$

- Mortality rate (in %) of kits of genotype $j = 0, 1$ from birth till weaning ($morbw[j]$) averaged over doe reproductive cycles ($morbw[j]$):

$$morbw[j] = 100 \times \frac{nbat[j] - nbwt[j]}{nbat[j]} \tag{2.63}$$

- Survival rate (in %) of kits of genotype $j = 0, 1$ from birth till weaning ($surbw[j]$) averaged over doe reproductive cycles ($surbw[j]$):

$$surbw[j] = 100 \times \frac{nbwt[j]}{nbat[j]} \tag{2.64}$$

- Survival rate (%) of animals of genotype $j = 0, 1$ in fattening ($srfP[j]$):

$$srfP[j] = 100 \times (1 - pdiedfP[j]) \tag{2.65}$$

2.4.2.3 Numbers of animals in categories 1 to 3

The following variables are calculated with index $j = 0$ (purebred progeny) if $bsyst < 3$ and with index $j = 1$ (crossbred progeny) if $bsyst > 1$.

- Number of stillborn kits (category 1) of genotype $j = 0, 1$ per doe and per reproductive cycle:

$$l1P[1][j] = nbt[j] - nbat[j] \tag{2.66}$$

- Number of kits of genotype $j = 0, 1$ died till weaning (category 2) per doe and per reproductive cycle:

$$l1P[2][j] = nbat[j] - nwt[j] \tag{2.67}$$

- Number of kits of genotype $j = 0, 1$ surviving till weaning (category 3) per doe and per reproductive cycle:

$$l1P[3][j] = nwt[j] \tag{2.68}$$

The following 4 variables are calculated from the number of kits in category 3:

- Number of female kits of genotype $j = 0, 1$ alive at weaning per doe and per reproductive cycle ($nfP[j]$):

$$nfP[j] = l1P[3][j] \times pfP[j] \tag{2.69}$$

- Number of surplus female kits of genotype j at weaning per doe and per reproductive cycle ($nsfP[j]$) :

$$nsfP[j] = \begin{cases} nfP[j] - nurreplG & \text{for } j = 0 \\ nfP[j] & \text{for } j = 1 \end{cases} \tag{2.70}$$

- Number of male kits of genotype $j = 0, 1$ alive at weaning per doe and per reproductive cycle ($nmP[j]$):

$$nmP[j] = l1P[3][j] - nfP[j] \tag{2.71}$$

- Number of surplus male kits of genotype j at weaning per doe and per reproductive cycle ($nsmP[j]$):

$$nsmP[j] = \begin{cases} nmP[j] - nurreplB[j] & \text{for } j = 0 \\ nmP[j] & \text{for } j = 1 \end{cases} \tag{2.72}$$

2.4.2.4 Categories 6 to 11 (young replacement does)

The numbers of animals for categories 6 to 11 in Production system 1 and 2 are calculated only for purebred progeny (second index $j = 0$). In Production system 3 with crossbred does, the categories 8 to 11 exists: category 8 are replacement young does purchased before mating, categories 9 to 11 have the same meaning as in Production systems 1 and 2. But also in Production system 3, the second index has the value of zero ($j = 0$), because these young does are of the same genotype as the adult does.

- Number of young replacement does (category 6) died during rearing per doe per reproductive cycle (calculated only if bsyst$<$3) is:

$$l1P[6][0] = (nurreplG + nsfP[0] \times pexG[0]) \times pdiedG \tag{2.73}$$

- Number of young replacement does sold (exported) outside the evaluated production system during rearing (category 7, only calculated if $pexG[0] > 0$)[11] per doe per reproductive cycle (calculated only if bsyst$<$3) is:

$$l1P[7][0] = nsfP[0] \times pexG[0] \times (1 - pdiedG) \tag{2.74}$$

[11] The value of $pexG[0]$ is given in input file INPUTR03.TXT (see Subsection 7.1.4 on page 81).

The following equation are calculated for all production systems:

- Number of young replacement does firstly mated (category 8[12]) per doe per reproductive cycle:

$$l1P[8][0] = nmat1G \tag{2.75}$$

- Number of doe replacements (not conceived after 1st mating) mated for the 2nd time in the next mating cycle (category 9) per doe per reproductive cycle:

$$l1P[9][0] = nmat2G \tag{2.76}$$

- Number of young replacement does mated, but culled for failure to conceive after the 1st or 2nd mating (category 10) per doe per reproductive cycle[13]:

$$l1P[10][0] = nmat1G \times (1 - con1G) \times (1 - pbarrG) + nmat2G \times (1 - con2G) \tag{2.77}$$

- Number of young breeding does having first kindling (category 11) per doe per reproductive cycle:

$$l1P[11][0] = l2D[1] \tag{2.78}$$

2.4.2.5 Categories 12 to 16 (breeding bucks)

The frequencies of categories 12, 15 and 16 are not calculated in the Production systems 3 (i.e. if $bsyst = 3$, system with crossbreed does), because the bucks or their sperm are purchased from production systems with different breeds. The bucks purchased for natural mating in Production system 3 and bucks purchased for crossing in Production system 2 are treated as categories 13 and 14 with index 1 for buck genotype ($l1P[13][1]$) ($l1P[14][1]$).

- Number of young replacement bucks died during the rearing period (category 12) per doe per reproductive cycle (calculated only if bsyst<3):

$$l1P[12][0] = nurreplB[0] \times pdiedB[0] \tag{2.79}$$

- Number of young replacement bucks reared for purebreeding ($j = 0$, in Production systems 1 and 2) or bought for crossbreeding ($j = 1$, in Production systems 2 and 3) using natural mating but, culled for unsuitability for mating (category 13) per doe per reproductive cycle (calculated only if mating type is 2 ($mtype[j] = 2$) :

$$l1P[13][j] = numnmyB[j] \times pcullB[j] \tag{2.80}$$

- Number of young replacement bucks of genotype $j = 0$ (if bsyst<3) and of genotype $j = 1$ (if bsyst>1) used for purebreeding or bought for crossbreeding using natural mating (category 14) per doe per reproductive cycle. This category is calculated if mating type is 2 ($mtype[j] = 2$):

$$l1P[14][j] = numnmyB[j] \times (1 - pcullB[j]) \tag{2.81}$$

- Number of young replacement bucks sold to insemination stations (category 15) per doe per reproductive cycle. This category is calculated if mating type is 1 ($mtype[0] = 1$) and Production system is less than 3 (bsyst<3):

$$l1P[15][0] = numspyB[0] \tag{2.82}$$

[12] In Production system 3, this is the number of purchased and mated young doe replacements

[13] It is assumed that replacement does not conceived at first mating can be mated only in the next mating cycle (only one re-mating for females is assumed)

- Number of surplus progeny sold as young replacement bucks (category 16) per doe per reproductive cycle (calculated only if bsyst$<$3 and if $pexB[0] > 0$) :

$$l1P[16][0] = nsmP[0] \times pexB[0] \tag{2.83}$$

2.4.2.6 Progeny categories 4 and 5

These categories are surplus kits which are not needed for replacement or for selling as breeding animals and are fattened. Variables with index $j = 0$ (purebred progeny) are calculated if $bsyst < 3$, variables with index $j = 1$ (crossbred progeny) are calculated if $bsyst > 1$,

- Number of animals of genotype $j = 0, 1$ died in the finishing phase (category 4) per doe per reproductive cycle:

$$l1P[4][j] = (nsfP[j] - l1P[7][j] + nsmP[j] - l1P[16][j]) \times pdiedfP[j] \tag{2.84}$$

- Number of animals of genotype $j = 0, 1$ finished to target slaughter weight (category 5) per doe per reproductive cycle:

$$l1P[5][j] = (nsfP[j] - l1P[7][j] + nsmP[j] - l1P[16][j]) \times (1 - pdiedfP[j]) \tag{2.85}$$

Chapter 3

Growth, DE energy and feed requirements

3.1 General strategy of modelling growth, digestible energy (DE) and feed requirement

The growth pattern of rabbits is approximated by a multi-phase growth curve assuming linear functions for the individual phases. The following phases of growth are distinguished:

- Growth of kits from birth till 21th day of age
- Growth of kits from 21th day of age till weaning
- Growth of kits from weaning to slaughter after finishing
- Growth of young replacement does from weaning to 1st mating
- Growth of young replacement does not conceived at 1st mating in the period from 1st to 2nd mating
- Growth of young replacement does during pregnancy
- Growth of young replacement bucks from weaning to reaching mature weight
- Growth and change of body weight of does during reproductive cycles

Growth of animals is characterised by the rate of protein and lipid (fat) deposition. Starting weight and growth rate (protein and fat gain) of animals in different time periods are the main parameters affecting digestible energy (DE) and feed requirement of young growing rabbits. Reproductive status of does (pregnancy, lactation) and their possibility to mobilise body reserves if their feed intake do not cover their requirements are the most important for digestible energy and feed requirement of does. The chemical composition of the kits at birth were used to estimated net energy retained in fetuses and DE requirement for fetal growth. Assuming ad libitum feeding of does the composition of kits at birth were taken from [13]: 888 g water, 120 g protein, 55 g fat, 22 g ash and net energy content 5 kJ per kg weight. These values were used as default input parameters in input file INPUTR06.TXT (see Section 7.1.7). As the experimental estimates of these values are often inconsistent in the literature, all the given values can be changed by the user of the program if appropriate data are available for the rabbit breed modelled.

It is assumed that suckling kits until the age of 21 days do not eat substantial amount of supplement feed next to doe milk. Therefore, the weights of litter at birth and at 21 days can be used to estimate the average milk yield of does in this period assuming that kit consumption of 1 kg doe milk allows 0.56 kg gain of kits [4]. After the age of 21 days, generally, a supplementary preweaning diet is given to kits until weaning. Litter weight at weaning and the amount of supplementary feed consumed by kits from the age of 21 days to weaning can be used to estimate milk production of does in this period, in which does can be pregnant.

For the growing rabbits from weaning to slaughter and for reared replacements, the following composition of empty body gain (EBG) were assumed and used as default input parameters (in input file INPUTR07.TXT, see Section 7.1.8) to calculate DE and feed requirement (taken from [13]): 610 g water, 210 g protein, 150 g fat and 30 g ash per kg EBG. Again, because no unique estimates of these values are given in the literature, these parameters can be change by the program users, if different estimates are available for the evaluated breed. The same composition of EBG is assumed for young replacement bucks and for young non-pregnant replacement does and for young does in early and mid-gestation (0-21 days).

On the base of this gain composition digestible energy requirement and amount of feed for growth is calculated. Digestible energy and feed requirement for maintenance is estimated according to average metabolic body weight of animal in the appropriate growth period.

The growth or loss of body weight during high gestation and lactation of does is modelled according [13] on the base of does average body weight, weight at kindling, at the 21th day of lactation (parameters given in input file INPUTR01.TXT, see Section 7.1.2) and on chemical composition of doe body (in input file INPUTR08.TXT, see Section 7.1.9).

3.2 Calculation of some parameters connected with growth periods of progeny

In this section, index j is used for the genotype of the progeny, where $j = 0$ stands for purebred progeny and $j = 1$ is used for crossbred progeny. In the calculations for the crossbred does in Production system 3, there is no purebred progeny and, more generally speaking, also no progeny of the same genotype as the genotype of the does. Therefore in this system, most variables will be calculated only for $j = 1$, while the progeny categories 6 to 7 and 12 to 16 do not exists. Further in this system, it is assumed that all replacement does are purchased at the time of their first mating. Therefore, calculation for these replacements involves only categories 8 to 11, while these categories have the index $j = 0$, because they have the same genotype as the adult does.

- Age (d) of progeny category 2[1] ($ageP[2][j]$):

$$ageP[2][j] = agew/2.0 \tag{3.1}$$

- Age (d) of progeny category 3 ($ageP[3][j]$), is equal to the input variable age at weaning:

$$ageP[3][j] = agew \tag{3.2}$$

- Age (d) of progeny category 5 ($ageP[5][j]$), i.e. age at slaughter:

$$ageP[5][j] = agew + \frac{(wP[5][j] - wP[3][j]) \times 1000.0}{adgP[5][j]}\ , \tag{3.3}$$

[1] For simplicity, dying of animal is assumed to be in average in the middle of the period birth to weaning

where target weight at the end of finishing ($wP[5][j]$) is given in kg and daily gain ($adgP[5][j]$) in g/day.

- Age (d) of progeny category 4[2] ($ageP[4][j]$):

$$ageP[4][j] = agew + (ageP[5][j] - agew)/2.0 \tag{3.4}$$

For category 4, the same daily gain is assumed as for category 5, therefore

$$adgP[4][j] = adgP[5][j] \ . \tag{3.5}$$

.

- Average daily gain (in g/day) of sold purebred ($j = 0$) or crossbred ($j = 1$) young replacement does (category 7) from weaning till selling ($adgP[7][j]$) is calculated only if $pexpG[j] > 0$, where variables with $j = 0$ are calculated if $bsyst < 3$ and with $j = 1$ $bsyst = 2$ as:

$$adgP[7][j] = \frac{(wP[7][j] - wP[3][j]) \times 1000.0}{ageP[7][j] - ageP[3][j]} \ , \tag{3.6}$$

- Average daily gain (in g/day) of kit genotype $j = 0, 1$ between the 21th day of age until weaning ($adgP[3][j]$) is:

$$adgP[3][j] = \frac{(wP[3][j] - w21[j]) \times 1000.0}{agew - 21} \ , \tag{3.7}$$

The following four equations are calculated only if $bsyst < 3$:

- Age (d) of progeny category 6[3] ($ageP[6][0]$):

$$ageP[6][0] = agew + \frac{(ageP[8][0] - agew)}{2.0} \tag{3.8}$$

- Average daily gain (in g/day) of own reared purebred young replacement does (category 8) from weaning till first mating ($adgP[8][0]$) is calculated only if $bsyst < 3$ as:

$$adgP[8][0] = \frac{(wP[8][0] - wP[3][0]) \times 1000.0}{ageP[8][0] - ageP[3][0]} \ , \tag{3.9}$$

where $wP[8][0]$ and $ageP[8][0]$ are input parameters in all Production systems (see 7.1.4).

- Average daily gain (in g/day) of purchased crossbred replacement does (category 8) in Production system 3 from purchase to first mating ($adgP[8][0]$) is calculated as:

$$adgP[8][0] = \frac{(wP[8][0] - wpF) \times 1000.0}{ageP[8][0] - agepF} \ , \tag{3.10}$$

, where wpF (weight of female replacement at purchase) and $agepF$ (age of female replacement at purchase) are input parameters in INPUTR03.TXT (see 7.1.4).

[2] For simplicity, dying of animal is assumed to be in average in the middle of the finishing period
[3] For simplicity, dying of animal is assumed to be in average in the middle of the finishing period

- The same daily gain is assumed for category 6 (replacement does died in rearing, only in Production systems 1 and 2), therefore

$$adgP[6][0] = adgP[8][0] \ . \tag{3.11}$$

.

- Weight of category 6 at dying ($wP[6][0]$) is calculated as:

$$wP[6][0] = wP[3][0] + adgP[6][0] \times (ageP[6][0] - ageP[3][0])/1000 \tag{3.12}$$

The following 14 equations are valid for all production systems.

The following seven variables are calculated if the variable in input file INPUTR03.TXT $pbarrG > 0$. The second index of the variables is 0 also in Production system 3, because the purchased crossbred young does are of the same genotype as the adult does in the herds.

- Age (d) of category 9 (age of replacement does at 2nd mating) ($ageP[9][0]$) is calculated as:

$$ageP[9][0] = ageP[8][0] + lpreg + intkm \tag{3.13}$$

- Average daily gain (in g/day) of purebred young replacement does not pregnant after the first mating, but kept to the second mating (category 9) from first to second mating ($adgP[9][0]$) is calculated as:

$$adgP[9][0] = \frac{(wP[9][0] - wP[8][0]) \times 1000.0}{ageP[9][0] - ageP[8][0]} \ , \tag{3.14}$$

where $wP[9][0]$ is target weight of young does[4] at 2nd mating (input parameter in file INPUTR03.TXT, see Subsection 7.1.4).

The following equations for categories 10 and 11 are applied to simplify the calculation of feed requirements for these categories:

- Average age (d) of category 10 ($ageP[10][0]$) is calculated as a weighted average from the ages of does culled after the first and the second mating:

$$\begin{aligned} ageP[10][0] \quad = \quad & \Big((ageP[8][0] + inmcG) \times (1 - con1G) * (1 - pbarrG) + \\ & (ageP[8][0] + lpreg + intkm + inmcG) \times (1 - con1G) \\ & \times pbarrG \times (1 - con2G)\Big) / \Big((1 - con1G) * (1 - pbarrG) \\ & + (1 - con1G) \times pbarrG \times (1 - con2G)\Big) \end{aligned} \tag{3.15}$$

- Average weight (kg) of category 10 ($wP[10][0]$) is calculated as a weighted average from the weights of does culled after the first and the second mating:

$$\begin{aligned} wP[10][0] \quad = \quad & \Big((wP[8][0] + inmcG \times adgP[9][0]/1000.0) \times (1 - con1G) \\ & * (1 - pbarrG) + (wP[9][0] + inmcG \times adgP[9][0]/1000.0) \\ & \times (1 - con1G) \times pbarrG \times (1 - con2G)\Big) / \Big((1 - con1G) \\ & * (1 - pbarrG) + (1 - con1G) \times pbarrG \times (1 - con2G)\Big) \end{aligned} \tag{3.16}$$

[4] Restricted feeding is assumed for these young does to insure that the animal will be not too fat

- Average age (d) at mating (conceiving) of replacement does ($ageavmat[0]$) is calculated as weighted average from the age at 1st and 2nd mating of replacement does:

$$\begin{aligned} ageavmat[0] &= \Big((ageP[8][0]) \times con1G + ageP[9][0] \times (1 - con1G) \\ &\quad \times pbarrG \times con2G\Big) / \Big(con1G + (1 - con1G) \\ &\quad \times pbarrG \times con2G\Big) \end{aligned} \tag{3.17}$$

- Average weight (kg) at mating (conceiving) of replacement does ($wavmat[0]$) is calculated as weighted average from the weight at 1st and 2nd mating of replacement does:

$$\begin{aligned} wavmat[0] &= \Big((wP[8][0]) \times con1G + wP[9][0] \times (1 - con1G) \\ &\quad \times pbarrG \times con2G\Big) / \Big(con1G + (1 - con1G) \\ &\quad \times pbarrG \times con2G\Big) \end{aligned} \tag{3.18}$$

- Average age (d) of category 11 (average age at 1st kindling) is calculated as a weighted average from the age replacement does conceived after the first mating and those conceived after the second mating: ($ageP[11][0]$):

$$\begin{aligned} ageP[11][0] &= \Big((ageP[8][0] + lpreg) \times con1G \\ &\quad + (ageP[8][0] + 2.0 \times lpreg + intkm) \\ &\quad \times (1 - con1G) \times pbarrG \times con2G\Big) / \Big(con1G + (1 - con1G) \\ &\quad \times pbarrG \times con2G\Big) \end{aligned} \tag{3.19}$$

For the case that $pbarrG = 0$, category 9 does not exists. Variables connected with categories 10 and 11 in the case that $pbarrG = 0$ are then calculated as shown in the following 5 equations:

- Average age (d) of category 10 ($ageP[10][0]$) is:

$$ageP[10][0] = ageP[8][0] + inmcG \tag{3.20}$$

- Average weight (kg) of category 10 ($wP[10][0]$) is:

$$wP[10][0] = wP[8][0] + inmcG \times adgP[8][0]/1000.0) \tag{3.21}$$

- Average age (d) at mating (conceiving) of replacement does ($ageavmat[0]$) is:

$$ageavmat[0] = ageP[8][0]) \tag{3.22}$$

- Average weight (kg) at mating (conceiving) of replacement does ($wavmat[0]$) is:

$$wavmat[0] = wP[8][0] \tag{3.23}$$

- Average age (d) of category 11 (average age at 1st kindling) ($ageP[11][0]$) is:

$$ageP[11][0] = ageP[8][0] + lpreg \tag{3.24}$$

The following two variables are calculated for both cases ($pbarrG > 0$ and $pbarrG = 0$).

- Average daily gain (in g/day) of young replacement does not pregnant after the first mating and culled (category 10) from mating to culling ($adgP[10][0]$) is calculated as:

$$adgP[10][0] = \frac{(wP[10][0] - wavmat[0]) \times 1000.0}{ageP[10][0] - ageavmat[0]} , \tag{3.25}$$

- Average daily gain (in g/day) of body weight of young replacement does from mating[5] to 1st kindling (category 11) ($adgP[11][0]$) excluding growth of fetuses is calculated as:

$$adgP[11][0] = \frac{(wfD[1] - wavmat[0]) \times 1000.0}{ageP[11][0] - ageavmat[0]} , \tag{3.26}$$

The following eight variables for young breeding bucks are calculated if bsyst < 3:
If $mtype[0] = 1$ the following variables are calculated:

- Average age (d) of young bucks reared for sperm production but died in rearing (category 12) ($ageP[12][0]$) is :

$$ageP[12][0] = ageP[3][0] + (ageP[15][0] - ageP[3][0])/2.0 \tag{3.27}$$

- Average daily gain (in g/day) of young replacement bucks category 12 ($adgP[12][0]$) and category 15 ($adgP[15][0]$) is calculated as:

$$adgP[12][0] = adgP[15][0] = \frac{(wP[15][0] - wP[3][0]) \times 1000.0}{ageP[15][0] - ageP[3][0]} , \tag{3.28}$$

- Average weight (kg) at dying of young breeding bucks of category 12 ($wP[12][0]$) is :

$$wP[12][0] = wP[3][0] + (ageP[12][0] - ageP[3][0]) \times \frac{adgP[12][0]}{1000.0} \tag{3.29}$$

If $mtype[0] = 2$ the following variables are calculated:

- Average age (d) of young bucks reared for natural mating but died in rearing (category 12) ($ageP[12][0]$) is :

$$ageP[12][0] = ageP[3][0] + (ageP[14][0] - ageP[3][0])/2.0 \tag{3.30}$$

- Average daily gain (in g/day) of young replacement bucks category 12 ($adgP[12][0]$) and 14 ($adgP[14][0]$) is calculated as:

$$adgP[12][0] = adgP[14][0] = \frac{(wP[14][0] - wP[3][0]) \times 1000.0}{ageP[14][0] - ageP[3][0]} , \tag{3.31}$$

- Average weight (kg) at dying of young breeding bucks of category 12 ($wP[12][0]$) reared for natural mating is :

$$wP[12][0] = wP[3][0] + (ageP[12][0] - ageP[3][0]) \times \frac{adgP[12][0]}{1000.0} \tag{3.32}$$

[5] The weight and age at mating for category 11 were calculated as weighted average from weight and age of replacement does conceived after first (category 8) and second mating (category 9), if second mating was allowed for replacement does, i.e. if pbarrG>0.

- Average daily gain (in g/day) of young replacement bucks reared for natural mating, but culled for unsuitability for mating (category 13, $adgP[13][0]$) is calculated as:

$$adgP[13][0] = \frac{(wP[13][0] - wP[3][0]) \times 1000.0}{ageP[13][0] - ageP[3][0]} \ , \tag{3.33}$$

If $pexB[0] > 0$ the following equation is calculated.

- Average daily gain (in g/day) of young replacement bucks sold (category 16, $adgP[16][0]$) is calculated as:

$$adgP[16][0] = \frac{(wP[16][0] - wP[3][0]) \times 1000.0}{ageP[16][0] - ageP[3][0]} \ , \tag{3.34}$$

If $bsyst > 1$ and $mtype[1] = 2$ the following two variables are calculated:

- Age (in days) of young replacement bucks purchased for crossing using natural mating, but culled for unsuitability for mating (category 13, $ageP[13][1]$) is assumed to be equal to the age of bucks of category 14:

$$ageP[13][1] = ageP[14][1] \ , \tag{3.35}$$

- Weight (in days) of young replacement bucks purchased for crossing using natural mating, but culled for unsuitability for mating (category 13, $wP[13][1]$) is assumed to be equal to the weight of bucks of category 14:

$$wP[13][1] = wP[14][1] \ , \tag{3.36}$$

In the following, the length of time a progeny category is defined is calculated, but only for those category of progeny with genotype $j = 0$ or $j = 1$ which exists in the evaluated production system:

- The time (d) for which genotype j of progeny category i ($i = 2, 3$) is defined ($dP[i][j]$):

$$\begin{aligned} dP[2][j] &= ageP[2][j] \\ dP[3][j] &= ageP[3][j] \end{aligned} \tag{3.37}$$

- The time (d) for which genotype j of progeny category i ($i = 4, \ldots, 8$) and ($i = 12, \ldots, 16$) is defined (in Production systems 1 and 2) ($dP[i][j]$):

$$dP[i][j] = ageP[i][j] - ageP[3][j] \tag{3.38}$$

- The time (d) for which the purchased replacement females of category 8 in Production system 3 is defined ($dP[8][0]$) is:

$$dP[8][0] = ageP[8][0] - agepF \tag{3.39}$$

- In the case that two fattening diets are used in rabbit fattening (i.e. if $nff = 2$), the time for which progeny category 5 is defined consists two periods $d1P[5][j]$ and $d2P[5][j]$:

$$d1P[5][j] = agefw2 - ageP[3][j] \tag{3.40}$$

$$d2P[5][j] = ageP[5][j] - agefw2 \tag{3.41}$$

- The time (d) for which genotype j of progeny category $i = 9$ is defined ($dP[9][0]$):

$$dP[9][0] = ageP[9][0] - ageP[8][0] \tag{3.42}$$

- The time (d) for which genotype j of progeny category i ($i = 10, 11$) is defined ($dP[i][0]$):

$$dP[i][0] = ageP[i][0] - ageavmat[0] \tag{3.43}$$

In Production system 3, i.e. if ($bsyst = 3$), the variable $dP[8][0] = 0$. If ($bsyst > 1$), the variables $dP[15][1] = dP[14][1] = 0$ and if in these systems ($pexG[1] > 0$) the time for crossbred progeny of category 7 is calculated as:

$$dP[7][1] = ageP[7][1] - ageP[3][1] \tag{3.44}$$

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3.3 Feeding diets assumed in rabbit production systems

The following diets are assumed to occur in rabbitry (the number of the diet is used as an index when calculating requirement of this diet for specific animal category):

1. Lactation diet (this diet is assumed for replacement does from certain day of pregnancy, for lactating and pregnant does)

2. Supplementary diet for kits from the age of 21 days until weaning (if lactation diets is used in this period, set the same digestible energy content and price for this diet as you have defined for diet 1 in input file INPUTR09.TXT, see 7.1.10)

3. Diet in fattening (if two phase fattening is applied, diet 3 is assumed for the first feeding phase)

4. Diet in the second fattening phase (if there is not phase fattening, this diet is skipped)

5. Specific diet for rearing of replacement does (if the same diet is applied for replacement does as in fattening, set the same digestible energy content and price for this diet as you have defined for diet in fattening, diet 3 or 4 in input file INPUTR09.TXT, see 7.1.10)

6. Diet for open does (if the same diet is applied for open does as in lactation, set the same digestible energy content and price for this diet as you have defined for lactation diet, if the same diet is applied for open does as in rabbit fattening, set the same digestible energy content and price for this diet as you have defined for fattening diet 3 or 4 in input file INPUTR09.TXT, see 7.1.10)

For rearing of breeding bucks, the same diet as for fattened animals is assumed. If one phase fattening is applied, diet 3 is automatically assumed. When two phase fattening exists, the program user is asked (in input file INPUTR09.TXT, see 7.1.10) which of the fattening diet is used for breeding bucks. In rearing of replacement does, a specific diet can be used (diet number 5). In the last third of pregnancy, the lactation diet (diet number 1) is assumed to be used for replacement does. The day of pregnancy when starting lactation diet for replacement does is an input parameter *dpregld* in INPUTR09.TXT.

3.4 Estimate of digestible energy (DE) and feed requirement in growing rabbits

The digestible energy and feed requirement is not calculated for progeny categories which died, i.e. for categories 4, 6, and 12 of the appropriate genotype $j = 0$ and/or $j = 1$. For simplicity, it is assumed that feeding costs for these categories were approximately half of the feeding costs for the appropriate category which stay in the herd for the whole time, i.e. for category 5 (for dead category 4), for category 8 (dead category 6) and for category 14, if $mtype[0] = 2$, or category 15, if $mtype[0] = 1$ (for dead category 12). All calculations given in this Section are made by the program only for progeny categories and genotypes which exists in the given Production system according to mating type and according to the values of the parameters $pexG[j]$ and $pexB[j]$. The following equations are written here in a general form. The conditions when a calculation is done or is not done for specific progeny category are not always mentioned here.

Calculation of empty body gain, protein and lipid gain

- Empty body daily gain ($ebgP[i][j]$), protein daily gain ($protgP[i][j]$) and lipid daily gain ($lipgP[i][j]$) (all in g/day) of progeny category i and genotype j ($j = 0$ for purebred animals and for replacement crossbred females of the same genotype as the genotype of does in Production system 3, $j = 1$ for crossbred animals) are calculated only for categories which exists in the specified Production system:

$$ebgP[i][j] = adgP[i][j] \times ebwP \tag{3.45}$$

$$protgP[i][j] = ebgP[i][j] \times pmassP[j] \tag{3.46}$$

$$lipgP[i][j] = ebgP[i][j] \times lmassP[j] \tag{3.47}$$

Calculation of the average metabolic live weight

- Average metabolic live weight ($mlwP[3][j]$) of a kit (category 3) from 22 day of age until weaning (in kg) is:

$$mlwP[3][j] = \left(w21[j] + \frac{wP[3][j] - w21[j]}{2}\right)^{bmP} \tag{3.48}$$

- Average metabolic live weight ($mlwP[i][j]$) of category $i = 5$ with genotypes $j = 0, 1$ and categories $i = 7, 8, 13, \ldots, 16$ in Production systems 1 and 2, with genotype $j = 0$ (in kg) (when these categories exist in the specified Production system) is :

$$mlwP[i][j] = \left(wP[3][j] + \frac{wP[i][j] - wP[3][j]}{2}\right)^{bmP} \tag{3.49}$$

- Average metabolic live weight ($mlwP[8][0]$) of category $i = 8$ in Production system 3 is :

$$mlwP[8][0] = \left(wpF + \frac{wP[8][0] - wpF}{2}\right)^{bmP} \tag{3.50}$$

- Average metabolic live weight ($mlwP[i][j]$) of category $i = 9$ with genotype $j = 0$ (in kg) is:

$$mlwP[9][0] = \left(wP[8][0] + \frac{wP[9][0] - wP[8][0]}{2}\right)^{bmP} \tag{3.51}$$

- Average metabolic live weight ($mlwP[i][j]$) of category $i = 10$ with genotype $j = 0$ (in kg) is:

$$mlwP[10][0] = \left(wavmat[0] + \frac{wP[10][0] - wavmat[0]}{2}\right)^{bmP} \tag{3.52}$$

Calculation of the daily digestible energy requirements for protein and lipid gain and for maintenance

- Digestible energy requirements in $kJ\ DE/day$ for protein gain ($deprotgP[i][j]$), for lipid gain ($delipgP[i][j]$) and for maintenance ($demP[i][j]$)[6] for category $i = 3$ from 21th day of age till weaning and for category $i = 5$, both with genotypes $j = 0, 1$, and for categories $i = 7, 8, 9, 10, 12, \ldots, 16$ with genotype $j = 0$ are calculated as:

$$deprotgP[i][j] = \frac{protgP[i][j] \times pneP}{kpP} \tag{3.53}$$

$$delipgP[i][j] = \frac{lipgP[i][j] \times lneP}{klP} \tag{3.54}$$

$$demP[i][j] = mlwP[i][j] \times smP \times 1000 \tag{3.55}$$

Calculation of the total daily digestible energy requirements

- Total digestible energy requirement ($dedayP[i][j]$) in $kJ\ DE/day$ for category $i = 3$ from 21th day of age till weaning and for category $i = 5$, both with genotypes $j = 0, 1$, and for categories $i = 7, 8, 9, 10, 12, \ldots, 16$ with genotype $j = 0$ is:

$$dedayP[i][j] = deprotgP[i][j] + delipgP[i][j] + demP[i][j] \tag{3.56}$$

Calculation of the required daily feed intake and of the total amount of feed of specific diet

The following equation are calculated for progeny category $i = 5$:

- Required feed intake in g/day of the fresh matter of the feeding diet number 3 (diet for the first fattening phase, if $nff = 2$, or for the whole fattening if only one diet is given during fattening, if $nff = 1$) is:

$$fP[3][5][j] = \frac{dedayP[5][j]}{defd[3]} \tag{3.57}$$

- Required feed intake in g/day of the fresh matter of the feeding diet number 4 (diet for the second fattening phase if it exists, i.e if $nff = 2$) is:

$$fP[4][5][j] = \frac{dedayP[5][j]}{defd[4]} \tag{3.58}$$

- Total amount of fresh feed matter from diets 3 (if $nff = 1$) per animal in fattening (in kg) taken into account feed wasting is then[7]:

$$tfP[3][5][j] = kfwf \times \frac{fP[3][5][j] \times dP[5][j]}{1000} \tag{3.59}$$

[6] The number 1000 in the equation for maintenance convert the value given in MJ to the value in kJ

[7] The number 1000 in the equations for feed amount convert the value given in g to the value in kg

- Total amount of fresh feed matter from diets 3 and 4 (if $nff = 2$) per animal in fattening (in kg) taken into account feed wasting is then:

$$tfP[3][5][j] = kfwf \times \frac{fP[3][5][j] \times d1P[5][j]}{1000} \tag{3.60}$$

$$tfP[4][5][j] = kfwf \times \frac{fP[4][5][j] \times d2P[5][j]}{1000} \tag{3.61}$$

The following equations are valid for progeny categories $i = 13, \ldots, 16$:

- Required feed intake in g/day of the fresh matter of the feeding diet j ($j = 3$ or $j = 4$ according to the input parameter nfb in INPUTR08.TXT) is:

$$fP[j][i][0] = \frac{dedayP[i][0]}{defd[j]} \tag{3.62}$$

- Total amount of fresh feed matter from feeding diet j ($j = 3$ or $j = 4$) per buck of category i, $i = 13, \ldots, 16$ in rearing (in kg) taken into account feed wasting is then:

$$tfP[j][i][0] = kfwr \times \frac{fP[j][i][0] \times dP[i][0]}{1000} \tag{3.63}$$

The following equations are valid for progeny categories $i = 8, \ldots, 10$ and genotype $j = 0$:

- Required feed intake in g/day of the fresh matter of the feeding diet number 5 ($fP[5][i][0]$, diet for rearing of replacement does) for young does of category i is:

$$fP[5][i][0] = \frac{dedayP[i][0]}{defd[5]} \tag{3.64}$$

- Amount of fresh feed matter from diet 5 per replacement doe of category i (in kg) taken into account feed wasting is then:

$$tfP[5][i][0] = kfwf \times \frac{fP[5][i][0] \times dP[i][0]}{\times 1000} \tag{3.65}$$

The following equations are valid for progeny category $i = 7$ and genotype $j = 0, 1$ (young breeding does sold):

- Required feed intake in g/day of the fresh matter of the feeding diet number 5 ($fP[5][7][j]$, diet for rearing of replacement does) for young does of category $i = 7$ is:

$$fP[5][7][j] = \frac{dedayP[7][j]}{defd[5]} \tag{3.66}$$

- Amount of fresh feed matter from diet 5 per replacement doe of category $i = 7$ and genotype $j = 0, 1$ (in kg) taken into account feed wasting is then:

$$tfP[5][7][j] = kfwf \times \frac{fP[5][7][j] \times dP[7][j]}{1000} \tag{3.67}$$

3.5 Digestible energy and feed requirement for replacement does of category 11

For simplicity, the starting weight and age of this category are defined as weighted averages from the weights and ages of replacement does conceived after their first and second mating. The period, for which digestible energy and feed requirement is calculate, is the period from conceiving (i.e. from mating) to kindling. In this period, the feed digestible energy should cover energy requirement for maintenance, growth of protein and lipid in empty body of does and growth of fetuses.

The following variables connected with pregnancy had to be calculated in which the first index means parity after which does were pregnant and the second index is for the genotype of fetuses the ($j = 0$ stand for purebred $j = 1$ for crossbred litters). For pregnant replacement does, the first index is zero, because these does did not have kindling yet.

- Total weight gain of fetuses (in kg) of the purebred ($j = 0$) or crossbred ($j = 1$) litters during pregnancy of replacement does, i.e. before first kindling (the first index $i = 0$ means parity of females), ($twgfetus[0][j]$) is:

$$twgfetus[0][j] = bw[j] \times nb[1][j] \tag{3.68}$$

- Average metabolic weight of fetuses (in kg^{bmP}) of the purebred ($j = 0$) or crossbred ($j = 1$) litters during pregnancy of replacement does (i.e before first kindling) ($mwfetus[0][j]$) is:

$$mwfetus[0][j] = \Big(\frac{twgfetus[0][j]}{2.0}\Big)^{bmP} \tag{3.69}$$

- Total protein gain (in kg) of fetuses of the purebred ($j = 0$) or crossbred ($j = 1$) litters during pregnancy of replacement does ($pgfetus[0][j]$) is:

$$wpfetus[0][j] = twgfetus[0][j] \times pmassb[j] \tag{3.70}$$

- Total fat (lipid) gain (in kg) of fetuses of the purebred ($j = 0$) or crossbred ($j = 1$) litters during pregnancy of replacement does ($plfetus[0][j]$) is:

$$wlfetus[0][j] = twgfetus[0][j] \times lmassb[j] \tag{3.71}$$

- Digestible energy needed for maintenance (in MJ DE) of fetuses of the purebred ($j = 0$) or crossbred ($j = 1$) litters during pregnancy of replacement does ($demfetus[0][j]$) is:

$$demfetus[0][j] = mwfetus[0][j] \times smP \times lpreg \tag{3.72}$$

- Total net energy needed for growth of fetuses (in MJ NE) of the purebred ($j = 0$) or crossbred ($j = 1$) litters during pregnancy of replacement does ($nefetus[0][j]$) is:

$$nefetus[0][j] = wpfetus[0][j] \times pneP + wlfetus[0][j] \times lneP \tag{3.73}$$

- Digestible energy needed for pregnancy (in MJ DE) for purebred ($j = 0$) or crossbred ($j = 1$) litters of replacement does ($defetus[i][j]$) is:

$$defetus[0][j] = \frac{nefetus[0][j]}{kpregD} + demfetus[0][j] \tag{3.74}$$

The following equations calculate variables connected with growth and energy requirement for replacement does of category 11. Variables that are not calculated for other progeny categories are designated with the number 11, which is not used as an index to save memory. Category 11 are replacement does of the same genotype as genotype of adult does (it exist also in Production system 3). Therefore, in the variables that exist also for other progeny categories, the index for genotype of replacement does is zero $j = 0$.

- Empty body weight (in kg) of replacement does at mating ($ebwavmat11$) is is:
$$ebwavmat11 = wavmat[0] \times ebwP \tag{3.75}$$
- Empty body weight (in kg) of replacement does just after 1st kindling ($ebwpP11$ is is:
$$ebwpP11 = wfD[1] \times ebwD \tag{3.76}$$
- Protein gain (in kg) of replacement does from mating (conceiving) to 1st kindling ($tpgP11$) is is:
$$tpgP11 = ebwpP11 \times pmassD - ebwavmat11 \times pmassP[0] \tag{3.77}$$
- Lipid gain (in kg) of replacement does from mating (conceiving) to 1st kindling ($tlgP11$) is is:
$$tlgP11 = ebwpP11 \times lmassD - ebwavmat11 \times lmassP[0] \tag{3.78}$$
- Average metabolic weight (in kg^{bmP}) of replacement does from mating (conceiving) to 1st kindling, without fetuses ($mlwP[11][0]$) is:
$$mlwP[11][0] = \left(wavmat[0] + \frac{wfD[1] - wavmat[0]}{2}\right)^{bmP} \tag{3.79}$$
- Total digestible energy needed for maintenance (in MJ DE) of replacement does (not including digestible energy needed for maintenance of fetuses) from mating to 1st kindling ($tdemP11$) is:
$$tdemP11 = mlwP[11][0] \times smP \times lpreg \tag{3.80}$$
- Digestible energy needed for growth of empty body weight (in MJ DE) of replacement does from mating to 1st kindling ($tdegP11$) is:
$$tdegP11 = \frac{tpgP11 \times pneP}{kpP} + \frac{tlgP11 \times lneP}{klP} \tag{3.81}$$
- Total digestible energy (in MJ DE) needed for maintenance and growth of replacement does in the whole period from mating to 1st kindling, without fetuses ($tdeP11$) is:
$$tdeP11 = tdemP11 + tdegP11 \tag{3.82}$$
- Digestible energy required (in kJ DE/day) in average for replacement does in the period from mating to 1st kindling per day ($dedayP[11][0]$), not including energy for fetuses, is:
$$dedayP[11][0] = 1000.0 \times tdeP11/lpreg \tag{3.83}$$

- Required feed intake in g/day of the fresh matter of the feeding diet number 5 (first index) ($fP[5][11][0]$)(diet for rearing of replacement does) in the period from mating to the day of pregnancy when replacement does became lactation diet (diet number 1), not including feed for fetuses, is:

$$fP[5][11][0] = \frac{dedayP[11][0]}{defd[5]} \tag{3.84}$$

- Required feed intake in g/day of the fresh matter of the feeding diet number 1 ($fP[1][11][0]$) (lactation diet) in the period from the day of pregnancy, when replacement does became this diet, to kindling including requirement for pregnancy[8] calculated as weighted average from purebred and crossbred litters[9] is[10]:

$$fP[1][11][0] = \frac{dedayP[11][0] + \frac{(defetus[0][1] \times pcrossD[0] + defetus[0][0] \times (1 - pcrossD[0])}{lpreg - dpregld}}{defd[1]} \tag{3.85}$$

- Amount of fresh feed matter from diet 5 per replacement doe of category 11 (in kg) taken into account feed wasting is then:

$$tfP[5][11][0] = kfwd \times \frac{fP[5][11][0] \times (dP[11][0] - (lpreg - dpregld))}{1000} \tag{3.86}$$

- Amount of fresh feed matter from diet 1 per replacement doe of category 11 (in kg) taken into account feed wasting is then:

$$tfP[1][11][0] = kfwd \times \frac{fP[1][11][0] \times (lpreg - dpregld)}{1000} \tag{3.87}$$

3.6 Digestible energy and feed requirement for breeding bucks used for natural mating in doe herds

Digestible energy and feed requirement for bucks used for natural mating of genotype j, where $j = 0$ for bucks of the breed of the does (in Production systems 1 and 2) and $j = 1$ for bucks of breed different of the breed of does which are purchased and used for crossing in Production systems 2 and 3 (when natural mating is applied), is calculated for the time period from 1st mating to culling of bucks. The same diet is assumed for reproductive bucks as in fattening (the users are asked in input file INPUTR09.TXT, which of the fattening diets, 3 or 4 are used for these bucks). Until reaching mature weight, the DE and feed is required for growth and maintenance, from reaching mature weight to culling, the amount of DE and feed is calculated based on requirement for maintenance only[11].

[8] It is assumed that the fetal growth occur mostly in the last third of pregnancy when the lactation diet is fed, therefore, the total energy requirement for fetuses is covered with diet number 1 in our calculation.

[9] In Production systems 2 a part of does is mated with bucks of different breed

[10] the first index in the variable $defetus[i][j]$ means the parity, which is zero for replacement does, the second index means the genotype of litter, $j = 0$ for purebred litter, $j = 1$ for crossbred litter. The dimension of the variable is, therefore, $defetus[RR][J]$., where RR take the values from 0 to RR. The index in the variable $pcrossD[0]$ means also parity which is zero for replacement does.

[11] However, bucks also need some energy for the sperm production and sexual activity. We have not found any information to the back energy requirement for sexual activity and sperm production. Absence of this energy requirement can be leveled by increasing the coefficient for feed wasting $kfwrB$ in INPUTR09.TXT, see7.1.10.

- The length of period (in days) from first use of breeding bucks for mating to reaching mature weight $dmB[j]$ is:

$$dmB[j] = agemB[j] - ageP[14][j] \tag{3.88}$$

- The length of period (in days) from reaching mature weight of bucks to culling $dmcB[j]$ is:

$$dmcB[j] = ageP[14[j] + lifenmB[j] - agemB[j] \tag{3.89}$$

- Daily gain of bucks from their first used for mating to reaching mature weight ($adgB[j]$) in g/d is calculated as:

$$adgB[j] = \frac{(wmB[j] - wP[14][j]) \times 1000.0}{agemB[j] - ageP[14][j]} \tag{3.90}$$

- Empty body gain (in g/day) of bucks from their first used for mating to reaching mature weight ($ebgB[j]$) is:

$$ebgB[j] = adgB[j] \times ebwP \tag{3.91}$$

- Average protein gain (in g/day) of breeding bucks from their first used for mating to reaching mature weight ($protgB[j]$) is then:

$$protgB[j] = ebgB[j] \times pmassP[j] \tag{3.92}$$

- Average fat (lipid) gain (in g/day) of breeding bucks from their first used for mating to reaching mature weight ($lipgB[j]$) is then:

$$lipgB[j] = ebgB[j] \times lmassP[j] \tag{3.93}$$

- Average metabolic live weight ($mlwB[j]$) of breeding bucks (in kg) from their first used for mating to reaching mature weight is then:

$$mlwB[j] = \left(wP[14][j] + \frac{wmB[j] - wP[14][j]}{2}\right)^{bmP} \tag{3.94}$$

- Digestible energy requirements in kJ/day for protein gain ($deprotgB[j]$), for lipid gain ($delipgB[j]$) and for maintenance ($demB[j]$)[12] of breeding bucks from their first used for mating to reaching mature weight are calculated as:

$$deprotgB[j] = \frac{protgB[j] \times pneP}{kpP} \tag{3.95}$$

$$delipgB[j] = \frac{lipgB[j] \times lneP}{klP} \tag{3.96}$$

$$demB[j] = mlwB[j] \times smP \times 1000 \tag{3.97}$$

- Total digestible energy requirement ($dedayB[j]$) in kJ/day for breeding bucks from their first used for mating to reaching mature weight is:

$$dedayB[j] = deprotgB[j] + delipgB[j] + demB[j] \tag{3.98}$$

[12] The number 1000 convert the value given in MJ to the value given in kJ

- Required feed intake in g/day of the fresh matter of the feeding diet i ($i = 3$ or $i = 4$ according to the input parameter nfb in INPUTR08.TXT) for breeding bucks from their first used for mating to reaching mature weight is:

$$fB[i][j] = \frac{dedayB[j]}{defd[i]} \tag{3.99}$$

- Digestible energy requirements in kJ/day for maintenance of breeding bucks from reaching mature weight to culling ($demcB[j]$) is calculated as:

$$demcB[j] = wmB[j]^{bmP} \times smP \times 1000 \tag{3.100}$$

- Required feed intake in g/day of the fresh matter of the feeding diet i ($i = 3$ or $i = 4$ according to the input parameter nfb in INPUTR08.TXT) for breeding bucks from reaching mature weight to culling is:

$$fmB[i][j] = \frac{demcB[j]}{defd[i]} \tag{3.101}$$

- Total amount of fresh feed matter from feeding diet i ($i = 3$ or $i = 4$) per breeding buck from its first used for mating to culling (in kg) taken into account feed wasting is then[13]:

$$tfB[i][j] = kfwrB \times \frac{fB[i][j] \times dmB[j] + fmB[i][j] \times dmcB[j]}{1000} \tag{3.102}$$

3.7 Digestible energy and feed requirement for does at parity i (i=1,...,RR)

Calculating DE energy and feed requirement for does, the reproductive doe cycle (kindling interval) is divided into three parts. The first time interval is from kindling to the 21th day of lactation, the second from the 22th day of lactation to kit weaning, and the third from kit weaning to the next kindling.

3.7.1 Doe DE and feed requirements from kindling to the 21th day of lactation

In the lactation period from kindling to 21 days of lactation, it is assumed that kits do not consume substantial amount of supplementary feed next to milk and does are open or in low pregnancy. Therefore, the energy requirements of does cover the requirement for milk production, maintenance and growth of body weight if doe weight gain is positive in this period. If does lost body weight due to insufficient feed intake, a part of the total energy requirement is covered from body reserves (body fat). The following variables are calculated for this time period:

- Milk yield (in kg) on parity i ($i = 1, \ldots, RR$) of a doe bearing purebred ($j = 0$) or crossbred ($j = 1$) litter in the period between kindling and the 21th day of lactation ($milk21[i][j]$) estimated at the base of litter weight at birth (only number of live born kits) and at the 21th day of lactation (assuming the same number of kits as born alive), presuming that 1 kg milk equals 0.56 kg kit weight ([4]) is calculated as:

$$milk21[i][j] = \frac{(w21[j] - bw[j]) \times nba[i][j]}{0.56} \tag{3.103}$$

[13] The number 1000 convert the value given in g to the value given in kg

- Net energy retained in milk (MJ NE) in the period between kindling and the 21th day of lactation ($nemilk21[i][j]$) of a doe on parity i ($i = 1, \ldots, RR$) that was bearing purebred ($j = 0$) or crossbred ($j = 1$) litter is:

$$nemilk21[i][j] = milk21[i][j] \times milkneD \tag{3.104}$$

- Loss of weight (kg) during the first 21 days of lactation in parity i ($i = 1, \ldots, RR$) for a doe (averaged over purebred and crossbred litters) ($wloss21[i]$) is:

$$wloss21[i] = w21D[i] - wfD[i] \tag{3.105}$$

  If this value is negative, net energy available for milk production from body reserves ($nebr21[i]$) assuming a coefficient for the efficiency of utilisation of body energy reserves for milk in non-pregnant does ($kmbrnpD$) is calculated as:

If $wloss21[i] < 0.00001$:

$$nebr21[i] = \frac{-wloss21[i] \times neebwD}{kmbrnpD} \tag{3.106}$$

If the value $wloss21[i]$ is positive, $nebr21[i] = 0$ and the doe have increased its weight (i.e. young does on first parity are growing) and the requirement of DE from feed had to be calculated for growth of does:

- Protein gain (in kg) of growing does on parity i ($wloss21[i] > 0$) in the time period from kindling until the 21th day of lactation ($pgain21[i]$) is then:

$$pgain21[i] = wloss21[i] \times pmassD \tag{3.107}$$

- Lipid gain (in kg) of growing does on parity i ($wloss21[i] > 0$) in the time period from kindling until the 21th day of lactation ($lgain21[i]$) is then:

$$lgain21[i] = wloss21[i] \times lmassD \tag{3.108}$$

- Average metabolic weight (in kg) of does on parity i in the period from kindling to the 21th day of lactation ($mlw21[i]$) is:

$$mlw21[i] = \Big(wfD[i] + wloss21[i]/2.0\Big)^{bmP} \tag{3.109}$$

- Total digestible energy requirement in $MJ\ DE$ ($tde21[i][j]$) from feed for a doe on parity i ($i = 1, \ldots, RR$) bearing purebred ($j = 0$) or crossbred ($j = 1$) litter in the period between kindling and the 21th day of lactation is then:

$$\begin{aligned} tde21[i][j] \quad = \quad & \frac{nemilk21[i][j] - nebr21[i]}{kmilkD} + \frac{pgain21[i] \times pneD}{kpD} \\ & + \frac{lgain21[i] \times lneD}{klD} + mlw21[i] \times smD \times 21.0 \end{aligned} \tag{3.110}$$

- Total amount (in kg) of fresh feed matter of the feeding diet number 1 ($tf21D[1][i][j]$) (lactation diet) for does on parity i ($i = 1, \ldots, RR$) bearing purebred ($j = 0$) or crossbred ($j = 1$) litter in the period from kindling until the 21th day of lactation including feed wasting is:

$$tf21D[1][i][j] = kfwd \times \frac{tde21[i][j]}{defd[1]} \tag{3.111}$$

.

3.7.2 Doe DE and feed requirements from the 22th day of lactation to kits weaning

In this interval, it is assumed that kits are given a supplementary feed next to doe milk. Energy requirements for growth and maintenance of kits that is not obtained from the supplementary feed must be covered through doe milk. Therefore, in this period, the doe energy requirements is composed of energy requirements for milk production, maintenance and fetal growth if does are pregnant. Due to limited feed intake capacity of does in this period, a part of the energy requirement is covered through body reserves, i.e. generally, does lost body weight in this period. For non-pregnant does, energy requirements for milk production, maintenance and, in the case these does increase their body weight, also for this change in body weight are calculated. The following variables are calculated for this time period:

- Total net energy requirement (in $kJ\ NE$) for the whole purebred ($j = 0$) or crossbred ($j = 1$) litter of does on parity i ($i = 1, \ldots, RR$) in the period between the 22th day of kit age and weaning ($nelit21w[j]$) in kJ is:

$$nelit21w[i][j] = 0.5 \times (dedayP[3][j] \times (agew - 21) \times nw[i][j]) \tag{3.112}$$

  where 0.50 is the efficiency of DE utilization for EBW gain ([13]).

- Total net energy (in $MJ\ NE$) available from supplementary feed (diet 2, first index) for the whole purebred ($j = 0$) or crossbred ($j = 1$) litter of does in parity i ($i = 1, \ldots, RR$) in the period between the 22th day of kit age and weaning ($tnef[2][i][j]$) is

$$tnef[2][i][j] = \frac{tfP[2][3][j] \times nw[i][j]}{kfww} \times defd[2] \times 0.50 \tag{3.113}$$

  where index 3 means the progeny category 3.

- Net energy for the whole purebred ($j = 0$) or crossbred ($j = 1$) litter of does in parity i ($i = 1, \ldots, RR$) in the period between the 22th day of kit age and weaning ($nemilk21w[i][j]$) in $MJ\ NE$ that must be covered from milk is:

$$nemilk21w[i][j] = \frac{nelit21w[i][j]}{1000} - tnef[2][i][j] \tag{3.114}$$

  (The number 1000 convert the units kJ to MJ.

- Assuming the caloric value of doe milk $milkneD$ in MJ/kg, the produced milk amount (in kg) in the time period from 22th day of lactation to kit weaning of a doe in parity i ($i = 1, \ldots, RR$) which was bearing purebred ($j = 0$) or crossbred ($j = 1$) litter ($milkw[i][j]$) is:

$$milkw[i][j] = \frac{nemilk21w[i][j]}{milkneD} \tag{3.115}$$

- Loss of weight (kg) from the 22th day of lactation to kit weaning in parity i ($i = 1, \ldots, RR$) for a does ($wlossw[i]$) averaged over purebred and crossbred litters is:

$$wlossw[i] = wwD[i] - w21D[i] \tag{3.116}$$

If the value ($wlossw[i] < 0.00001$, net energy available for milk production on parity i from body reserves of pregnant does ($nebrwp[i][k]$) assuming coefficient for the

efficiency of utilisation of body energy reserves for milk in pregnant does $kmbrpD$ is:

$$nebrwp[i] = \frac{-wlosw[i] \times neebwD}{kmbrpD} \tag{3.117}$$

Net energy available for milk production on parity i from body reserves of non pregnant does ($nebrwnp[i]$) assuming coefficient for the efficiency of utilisation of body energy reserves for milk in non-pregnant does $kmbrnpD$ is:

$$nebrwnp[i] = \frac{-wlosw[i] \times neebwD}{kmbrnpD} \tag{3.118}$$

If the value $wlossw[i]$ is positive $nebrwp[i] = 0$ and $nebrwnp[i] = 0$, the does have increased their weight (through gain of empty body weight and/or fetal growth) and the requirement of DE from feed had to be calculated for growth of does :

- Protein gain of does ($pgainw[i]$) on parity i in the time period from the 22th day of lactation until kit weaning is then:

$$pgainw[i] = wlossw[i] \times pmassD \tag{3.119}$$

- Lipid gain of does ($lgainw[i]$) on parity i in the time period from the 22th day of lactation until kit weaning is then:

$$lgainw[i] = wlossw[i] \times lmassD \tag{3.120}$$

- Average metabolic weight of does ($mwwD[i]$) on parity i in the period from the 22th day of lactation until kit weaning is:

$$mlww[i] = \Big(w21D[i] + wlossw[i]/2.0\Big)^{bmP} \tag{3.121}$$

- Total digestible energy requirement in MJ from feed for a non-pregnant does ($tdewnp[i]$) or pregnant does ($tdewp[i]$) on parity i ($i = 1, \ldots, RR$) bearing purebred ($j = 0$) or crossbred ($j = 1$) litter in the period from the 22th day of lactation until kit weaning is then:

$$\begin{aligned} tdewnp[i][j] &= \frac{nemilk21w[i][j] - nebrwnp[i]}{kmilkD} + \frac{pgainw[i] \times pneD}{kpD} \\ &\quad + \frac{lgainw[i] \times lneD}{klD} + mlww[i] \times smD \times (agew - 21) \end{aligned} \tag{3.122}$$

$$\begin{aligned} tdewp[i][j] &= \frac{nemilk21w[i][j] - nebrwp[i]}{kmilkD} + \frac{pgainw[i] \times pneD}{kpD} \\ &\quad + \frac{lgainw[i] \times lneD}{klD} + mlww[i] \times smD \times (agew - 21) \end{aligned} \tag{3.123}$$

- Total amount (in kg) of fresh feed matter of the feeding diet number 1 (first index, lactation diet) for a non-pregnant does ($tfnpD[1][i][j]$) or pregnant does ($tfpD[1][i][j]$) on parity i ($i = 1, \ldots, RR$) bearing purebred ($j = 0$) or

crossbred ($j = 1$) litter in the period from the 22th day of lactation until kit weaning including feed wasting is:

$$tfwnpD[1][i][j] = kfwd \times \frac{tdewnp[i][j]}{defd[1]} \tag{3.124}$$

$$tfwpD[1][i][j] = \frac{tdewp[i][j]}{defd[1]} \times kfwd \tag{3.125}$$

.

3.7.3 Doe DE and feed requirements from kits weaning to the next kindling

In this period, does must be distinguished which were pregnant (does on state 5, i.e. doe categories $i = [(j-1)\times 5+5]$) and does which were not pregnant but were kept to the next reproductive cycle (does on state 4, i.e. doe categories $i = [(j-1)\times 5+4]$), where $(j = 1, \ldots, RR-1)$, see Subsection 2.2.1. Energy requirement in this period for both, pregnant and not pregnant does must cover the requirements for empty body weight gain and for maintenance. The pregnant does need further energy for fetal growth and maintenance.

The following equation are valid for both, pregnant and not pregnant does:

- Total empty body gain (in kg) for does after the i^{th} kindling ($i = 1, \ldots, RR-1$) in the period from kit weaning to the next kindling (without gain for fetuses in pregnant does) ($ebwgpD[i]$) is calculated using the appropriate coefficient ($ebwD$):
$$ebwgpD[i] = (wfD[i+1] - wwD[i]) \times ebwD \tag{3.126}$$
- Total protein gain (in kg) in EBW of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) in the period from kit weaning to the next kindling (without gain for fetuses in pregnant does) ($protgpD[i]$) is:
$$protgpD[i] = ebwgpD[i] \times pmassD \tag{3.127}$$
- Total lipid gain (in kg) in EBW of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) in the period from kit weaning to the next kindling (without gain for fetuses in pregnant does) ($lipgpD[i]$) is:
$$lipgpD[i] = ebwgpD[i] \times lmassD \tag{3.128}$$
- Average metabolic weight of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) in the period from kit weaning to the next kindling (without fetuses in pregnant does) ($mkwpD[i]$) is:
$$mkwpD[i] = \left(wwD[i] + \frac{wfD[i+1] - wwD[i]}{2}\right)^{bmP} \tag{3.129}$$
- Net energy retained (in $MJ\ NE$) in protein of the empty body weight gain ($neprotpD[i]$) of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) in the period from kit weaning and the next kindling is calculated as:
$$neprotpD[i] = protgpD[i] \times pneD \tag{3.130}$$
- Net energy retained (in $MJNE$) in lipid of the empty body weight gain ($nelippD[i]$) of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) in the period from kit weaning and the next kindling is calculated as:
$$nelippD[i] = lipgpD[i] \times lneD \tag{3.131}$$

- Digestible energy needed for maintenance $dempD[i]$ of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) in the period from kit weaning and the next kindling (without maintenance of fetuses in pregnant does) are calculated as:

$$dempD[i] = mkwpD[i] \times smD \times (fint - agew) \tag{3.132}$$

In the two following Sub-subsections, the equations are given that differ between pregnant and not pregnant does in the period from kit weaning and the next kindling time.

3.7.3.1 Does pregnant in the period from kits weaning and next kindling

Pregnant does are assumed to gain weight not only due to recovery of body reserves lost during lactation but also due to fetal growth. These does are fed with lactation diet (diet number 1). Because the same diet is given to lactating and pregnant does during the whole kindling interval, a simplified manner for the energy requirement for doe pregnancy is applied here setting the total weight gain for fetal growth only in the period from kits weaning to the next kindling.

The following variables are calculated for pregnant does in this time period:

- Total weight gain of fetuses (in kg) during the whole pregnancy ($twgfetus[i][j]$) of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) for a doe bearing at the next kindling purebred ($j = 0$) or crossbred ($j = 1$) litter is:

$$twgfetus[i][j] = bw[j] \ \times nb[i+1][j] \tag{3.133}$$

- Total protein gain of fetuses (in kg) during the whole pregnancy ($wpfetus[i][j]$) of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) for a doe bearing at the next kindling purebred ($j = 0$) or crossbred ($j = 1$) litter is:

$$wpfetus[i][j] = twgfetus[i][j] \times pmassb[j] \tag{3.134}$$

- Total lipid gain of fetuses (in kg) during the whole pregnancy ($wlfetus[i][j]$) of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) for a doe bearing at the next kindling purebred ($j = 0$) or crossbred ($j = 1$) litter is:

$$wlfetus[i][j] = twgfetus[i][j] \times lmassb[j] \tag{3.135}$$

- Average metabolic weight of fetuses (in kg^{bmP}) of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) for a doe bearing at the next kindling purebred ($j = 0$) or crossbred ($j = 1$) litter ($mwfetus[i][j]$) is:

$$mwfetus[i][j] = \Big(\frac{twgfetus[i][j]}{2.0}\Big)^{bmP} \tag{3.136}$$

- Digestible energy (in $MJ\ DE$) needed for maintenance $demfetus[i][j]$ of fetuses during pregnancy of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) for does bearing at the next kindling purebred ($j = 0$) or crossbred ($j = 1$) litter are calculated as:

$$demfetus[i][j] = mwfetus[i][j] \times smD \times lpreg \tag{3.137}$$

- Net energy (in $MJ\ NE$) needed for growth of fetuses ($nefetus[i][j]$) of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) for a doe bearing at the next kindling purebred ($j = 0$) or crossbred ($j = 1$) litter are calculated as:

$$nefetus[i][j] = wpfetus[i][j] \times pneD + wlfetus[i][j] \times lneD \tag{3.138}$$

- Digestible energy (in $MJ\ DE$) needed for pregnancy ($defetus[i][j]$) of does after the i^{th} kindling ($i = 1, \ldots, RR-1$) for a doe bearing at the next kindling purebred ($j = 0$) or crossbred ($j = 1$) litter are calculated as:

$$defetus[i][j] = \frac{nefetus[i][j]}{kpregD} + demfetus[i][j] \tag{3.139}$$

- Total digestible energy (in $MJ\ DE$) requirement for pregnant does after the i^{th} kindling ($i = 1, \ldots, RR-1$), bearing at the next kindling purebred ($j = 0$) or crossbred ($j = 1$) litter, in the period from kit weaning and the next kindling is:

$$\begin{aligned} tdepD[i][j] &= defetus[i][j] + \frac{neprotpD[i]}{kpD} + \frac{nelippD[i]}{klD} \\ &\quad + dempD[i] \end{aligned} \tag{3.140}$$

- Total amount (in kg) of fresh feed matter of the feeding diet number 1 ($tfwkpD[1][i][j]$) (lactation diet, first index) for a pregnant doe after the i^{th} kindling ($i = 1, \ldots, RR-1$), bearing at the next kindling purebred ($j = 0$) or crossbred ($j = 1$) litter, in the period from kit weaning and the next kindling including feed wasting is:

$$tfwkpD[1][i][j] = \frac{tdepD[i][j]}{defd[1]} \times kfwd \tag{3.141}$$

3.7.3.2 Does not pregnant in the period from kits weaning and next (theoretical) kindling time

- Total digestible energy requirement for non-pregnant does after the i^{th} kindling ($i = 1, \ldots, RR-2$) in the period from kit weaning and the next kindling time is:

$$tdenpD[i] = \frac{neprotpD[i]}{kpD} + \frac{nelippD[i]}{klD} + dempD[i] \tag{3.142}$$

- Total amount (in kg) of fresh feed matter of the feeding diet number 6 ($tfwknpD[6][i]$) (diet for open does) for a non-pregnant doe after the i^{th} kindling ($i = 1, \ldots, RR-2$), in the period from kit weaning and the next kindling time including feed wasting is:

$$tfwknpD[6][i] = \frac{tdenpD[i]}{defd[6]} \times kfwd \tag{3.143}$$

3.7.3.3 Non-pregnant does in the period from kits weaning till culling.

- Total empty body gain (in kg) for non-pregnant does after the i^{th} kindling ($i = 1, \ldots, RR-2$) in the period from kit weaning to culling ($ebwgnpcD[i]$) is calculated using the appropriate coefficient ($ebwD$):

$$ebwgnpcD[i] = (wcD[i] - wwD[i]) \times ebwD \tag{3.144}$$

- Total protein gain (in kg) in EBW of non-pregnant does after the i^{th} kindling ($i = 1, \ldots, RR-2$) in the period from kit weaning to culling ($protgnpcD[i]$) is:

$$protgnpcD[i] = ebwgnpcD[i] \times pmassD \tag{3.145}$$

- Total lipid gain (in kg) in EBW of non-pregnant does after the i^{th} kindling ($i = 1, \ldots, RR-2$) in the period from kit weaning to culling ($lipgnpcD[i]$) is:

$$lipgnpcD[i] = ebwgnpcD[i] \times pmassD \tag{3.146}$$

- Average metabolic weight of non-pregnant does after the i^{th} kindling ($i = 1, \ldots, RR-2$) in the period from kit weaning to culling ($mkwnpcD[i]$) is:

$$mkwnpcD[i] = \left(wwD[i] + \frac{wcD[i] - wwD[i]}{2}\right)^{bmP} \tag{3.147}$$

- Net energy retained (in $MJ\ NE$) in protein of the empty body weight gain ($neprotnpcD[i]$) of non-pregnant does after the i^{th} kindling ($i = 1, \ldots, RR-2$) in the period from kit weaning and culling is calculated as:

$$neprotnpcD[i] = protgnpcD[i] \times pneD \tag{3.148}$$

- Net energy retained (in $MJ\ NE$) in lipid of the empty body weight gain ($nelinpcD[i]$) of does after the i^{th} kindling ($i = 1, \ldots, RR-2$) in the period from kit weaning and culling is calculated as:

$$nelipnpcD[i] = lipgnpcD[i] \times lneD \tag{3.149}$$

- Digestible energy (in $MJ\ DE$) needed for maintenance $demnpcD[i]$ of non-pregnant does after the i^{th} kindling ($i = 1, \ldots, RR-2$) in the period from kit weaning and culling is calculated as:

$$demnpcD[i] = mkwnpcD[i] \times smD \times (intkm + inmcD - agew) \tag{3.150}$$

- Total digestible energy (in $MJ\ DE$)requirement for non-pregnant does after the i^{th} kindling ($i = 1, \ldots, RR-2$) in the period from kit weaning to culling is:

$$tdenpcD[i] = \frac{neprotnpcD[i]}{kpD} + \frac{nelipnpcD[i]}{klD} + demnpcD[i] \tag{3.151}$$

- Total amount (in kg) of fresh feed matter of the feeding diet number 6 ($tfwknpcD[6][i]$) (diet for open does) for a non-pregnant doe after the i^{th} kindling ($i = 1, \ldots, RR-2$), in the period from kit weaning and culling including feed wasting is:

$$tfwknpcD[6][i] = \frac{tdenpcD[i]}{defd[6]} \times kfwd \tag{3.152}$$

3.7.4 DE and feed requirements for open does entering a reproductive cycle without kindling

Does entering reproductive cycle i ($i = 2, \ldots, RR-1$) without kindling (state 4 of does in cycle $i-1$, see Subsection 2.2.1) can conceive in this cycle and will have kindling in cycle $i+1$ ($i = 2, \ldots, RR$) or can be culled for health problems without being mated or were mated, but failed to conceive in this cycle and is assumed to be culled.

3.7.4.1 Does entering a cycle without kindling and culled for health problems without being mated or culled for failure to conceive

For a doe entering reproductive cycle i ($i = 2, \ldots, RR-1$) without kindling and culled for health problems (does at state 2), DE and feed requirements are calculated for the period from entering a cycle to culling at time of weaning [14]and include requirements for EBW gain and for maintenance:

- EBW gain of does entering reproductive cycle i ($i = 2, \ldots, RR-1$) without kindling and culled for health problems at time of weaning ($ebwgnp2D[i]$) is:

$$ebwgnp2D[i] = (wcnpD[i] - wfD]i]) \times ebwD \tag{3.153}$$

- Total protein gain (in kg) in EBW gain of these does ($pgnp2D[i]$) is:

$$pgnp2D[i] = ebwgnp2D[i] \times pmassnpD \tag{3.154}$$

- Total lipid gain (in kg) in EBW of these does ($lgnp2D[i]$) is:

$$lgnp2D[i] = ebwgnp2D[i] \times lmassnpD \tag{3.155}$$

- Average metabolic weight of these does ($mnp2D[i]$) is:

$$mnp2D[i] = \left(wfD[i] + \frac{ebwgnp2D[i]}{2}\right)^{bmP} \tag{3.156}$$

Does entering a cycle without kindling and culled for health problems without being mated

- Total digestible energy requirement for these does is:

$$tdenp2D[i] = \frac{pgnp2D[i] \times pneD}{kpD} + \frac{lgnp2D[i] \times lneD}{klD} + mnp2D[i] \times smD \times agew \tag{3.157}$$

- Feed requirement in kg of the fresh matter of the feeding diet number 6 ($tfnp2D[6][i][j]$) (diet for open does, first index) for does entering reproductive cycle i ($i = 2, \ldots, RR-1$) without kindling and being culled (at weaning time) for health problems without being mated, including feed wasting, is:

$$tfnp2D[6][i] = \frac{tdenp2D[i]}{defd[6]} \times kfwd \tag{3.158}$$

.

Does entering a cycle without kindling, failed to conceive again and being culled

- Total digestible energy requirement for these does is:

$$\begin{aligned} tdenpc2D[i] \quad = \quad & \frac{pgnp2D[i] \times pneD}{kpD} + \frac{lgnp2D[i]}{klD} + \\ & mnp2D[i+1] \times smD \times (intkm + inmcD) \end{aligned} \tag{3.159}$$

- Feed requirement in kg of the fresh matter of the feeding diet number 6 ($tfnpc2D[6][i][j]$) (diet for open does, first index) for does entering reproductive cycle i ($i = 2, \ldots, RR-1$) without kindling, not conceived in this cycle and being culled, including feed wasting, is:

$$tfnpc2D[6][i] = \frac{tdenpc2D[i]}{defd[6]} \times kfwd \tag{3.160}$$

.

[14]For simplicity, the time of culling for these does was set the same as for does which had kindling, i.e. culling at weaning time

3.7.4.2 Does entering a cycle without kindling, conceived and have kindling

For a doe entering a reproductive cycle i without kindling, but conceived and started cycle $i+1$ with kindling, DE and feed requirements are calculated for the whole kindling interval and include requirements for EBW gain, for maintenance and for pregnancy. It is assumed that these does are fed with feeding diet for open does (diet number 6) from entering a cycle until high pregnancy (until day *dpregld* given in input file 7.1.10) and with lactation diet for the rest of the pregnancy period until kindling.

- EBW gain of does entering reproductive cycle i $(i = 2, \ldots, RR-1)$ without kindling, being pregnant in this cycle and have kindling in cycle i+1 ($ebwgnkpD[i]$) is:

$$ebwgnkpD[i] = (wfD[i+1] - wfD]i]) \times ebwD \tag{3.161}$$

- Total protein gain (in kg) in EBW of these does ($pgnkpD[i]$) is:

$$pgnkpD[i] = ebwgnkpD[i] \times pmassD \tag{3.162}$$

- Total lipid gain (in kg) in EBW of these does ($lgnkpD[i]$) is:

$$lgnkpD[i] = ebwgnkpD[i] \times lmassD \tag{3.163}$$

- Average metabolic weight of these does ($mnkpD[i]$) is:

$$mnkpD[i] = \left(wfD[i] + \frac{ebwgnkpD[i]}{2}\right)^{bmP} \tag{3.164}$$

- Digestible energy requirement (in $MJ\ DE$) for the period when does entering cycle i $(i = 2, \ldots, RR-1)$ without kindling are fed with feeding diet 6, $denkoD[i]$ (from entering a cycle until day *dpregld* of pregnancy) is:

$$\begin{aligned} denkoD[i] \quad = \quad & \left(\frac{\frac{pgnkpD[i] \times pneD]}{kpD} + \frac{lgnkpD[i] \times lneD}{klD}}{fintD} + mnkpD[i] \times smD\right) \\ & \times (fintD - lpreg + dpregld) \end{aligned} \tag{3.165}$$

- Total amount (in kg) of fresh feed matter of the feeding diet number 6 ($tfnkoD[6][i]$) (diet for open does, first index) for a doe entering reproductive cycle i $(i = 2, \ldots, RR-1)$ without kindling in the period from entering a cycle until day *dpregld* of pregnancy including feed wasting, is:

$$tfnkoD[6][i] = \frac{denkoD[i]}{defd[6]} \times kfwd \tag{3.166}$$

.

- Net energy retained in $MJ\ NE$ in fetuses ($nefetus[i][j]$) (including energy for fetal maintenance)[15] in does on the i^{th} reproductive cycle $(i = 2, \ldots, RR-1)$ bearing at $i+1$ kindling purebred $(j = 0)$ or crossbred $(j = 1)$ litter is calculated as in Eq. (3.138) and the digestible energy for fetus maintenance ($demfetus[i][j]$) is calculated as in Eq. (3.137)

[15] It is assumed that this energy is covered from lactation diet (diet number 1)

- Digestible energy requirement (in $MJDE$) for does entering reproductive cycle i ($i = 2, \ldots, RR-1$) without kindling in the period from the day of pregnancy the does get lactation diet (diet number 1) to kindling ($denkpD[i][j]$), bearing purebred ($j = 0$) or crossbred ($j = 1$) litter, is:

$$\begin{aligned} denkpD[i][j] &= \Big(\frac{\frac{pgnkpD[i]\times pneD]}{kpD} + \frac{lgnkpD[i]\times lneD}{klD}}{fintD} + mnkpD[i] \times smD\Big) \\ &\quad \times dpregld + \frac{nefetus[i][j]}{kpregD} + demfetus[i][j] \end{aligned} \tag{3.167}$$

- Total amount (in kg) of fresh feed matter of the feeding diet number 1 ($tfnkpD[1][i][j]$) in the period from the day of pregnancy the does get lactation diet (diet number 1) to kindling, for a doe entering reproductive cycle i ($i = 2, \ldots, RR-1$) without kindling, being pregnant in this cycle, have kindling in reproductive cycle $i+1$ and bearing purebred ($j = 0$) or crossbred ($j = 1$) litter, including feed wasting, is:

$$tfnkpD[1][i][j] = \frac{denkpD[i][j]}{defd[1]} \times kfwd \tag{3.168}$$

.

3.7.5 Feed requirement for all doe categories

Feed requirement (in kg) is calculated for doe categories i where i is calculated in dependency on reproductive cycle j ($j = 1, \ldots, RR$) as follows:

$$i = \begin{cases} [(j-1)\times 5 + k] & \text{for } j = 1, \ldots, RR-2 \quad \text{and } k = 2,3,4,5 \\ [(j-1)\times 5 + k] & \text{for } j = RR-1 \quad \text{and } k = 2,3,5 \\ [(j-1)\times 5 + k] & \text{for } j = RR \quad \text{for } k = 2 \end{cases} . \tag{3.169}$$

Variable for feed requirement of doe category i from feed diet k is designated $fD[i][k]$ where the index i has the dimension C and index k has the dimension FP.

Feed requirement for does categories on the first reproductive cycle

- Does of category $i = 2$ are does at reproductive cycle $j = 1$ which were called after kits weaning for health problems without being mated. Feed requirement for this category ($fD[2][1]$) is covered from lactation diet (diet number 1) and is calculated as:

$$\begin{aligned} fD[2][1] &= (tf21D[1][1][0] + tfwnpD[1][1][0]) \times (1 - pcrossD[0]) \\ &\quad + (tf21D[1][1][1] + tfwnpD[1][1][1]) \times pcrossD[0] \end{aligned} \tag{3.170}$$

where $crossD[0]$ is the fraction of crossed replacement does.

- Does of category $i = 3$ are does at reproductive cycle $j = 1$ which were called for failure to conceive. Feed requirement for this category is covered with lactation diet (diet number 1) until kits weaning ($fD[3][1]$) and with diet for open does (diet number 6) ($fD[3][6]$) from weaning to culling:

$$fD[3][1] = fD[2][1] \tag{3.171}$$

$$fD[3][6] = tfwknpcD[6][1] \tag{3.172}$$

- Does of category $i = 4$ are does at reproductive cycle $j = 1$ which failed to conceive in this cycle, but were kept to the next cycle $j = 2$ to be mated again in this cycle. Feed requirement for this category is covered with lactation diet (diet number 1) until kits weaning ($fD[4][1]$) and with diet for open does (diet number 6) ($fD[4][6]$) from weaning to starting next reproduction cycle without kindling. The feed requirement of diets number 1 and 6 is then:

$$fD[4][1] = fD[3][1] \tag{3.173}$$

$$fD[4][6] = tfwknpD[6][1] \tag{3.174}$$

- Does of category $i = 5$ (first index) are does at first reproductive cycle which were pregnant and have next kindling. Feed requirement for this category ($fD[5][1]$) is covered from lactation diet (diet number 1, second index) and is calculated as:

$$\begin{aligned} fD[5][1] \quad = \quad & (tf21D[1][1][0] + tfwpD[1][1][0]) \times (1 - pcrossD[0]) \\ & + tfwkpD[1][1][0] \times (1 - pcrossD[1]) \\ & + (tf21D[1][1][1] + tfwpD[1][1][1]) \times pcrossD[0] \\ & + tfwkpD[1][1][1] \times pcrossD[1] \end{aligned} \tag{3.175}$$

Feed requirement for does categories on reproductive cycles 2 to RR-1

Does which belong to state 2, 3 and 5 in reproductive cycles 2 to RR-1 (i.e. does of categories $i = [(j-1) \times 5 + 2]$, $i = [(j-1) \times 5 + 3]$ and $i = [(j-1) \times 5 + 5]$ where $j = 2, \ldots, RR-1$) can be does entering the cycle with kindling (those coming from does at state 5 on previous cycle) or does entering the cycle without kindling (those coming from does at state 4 on previous cycle). Does which belong to state 4 in reproductive cycles 2 to RR-1 (i.e. does of categories $i = [(j-1) \times 5 + 4]$) are only does entering the cycle with kindling (those coming from does at state 5 on previous cycle) [16]. First, does entering cycle j ($j = 2, \ldots RR$) with ($p5[j]$) and without ($p4[j]$) kindling, respectively, expressed as a fraction of does entering cycle j had to be calculated as:

$$p5[j] = \frac{l1D[(j-2) \times 5 + 5]}{l1D[(j-2) \times 5 + 5] + l1D[(j-2) \times 5 + 4]} \tag{3.176}$$

$$p4[j] = \frac{l1D[(j-2) \times 5 + 4]}{l1D[(j-2) \times 5 + 5] + l1D[(j-2) \times 5 + 4]} \tag{3.177}$$

Then, the following calculations have to be done.

- Feed requirement for does of categories $i = [(j-1) \times 5 + 2]$ where $j = 2, \ldots, RR-1$) is:

$$\begin{aligned} fD[(j-1) \times 5 + 2][1] \quad = \quad & \Big((tf21D[1][j][0] + tfwnpD[1][j][0]) \\ & \times (1 - pcrossD[j-1]) \\ & + (tf21D[1][j][1] + tfwnpD[1][j][1]) \\ & \times pcrossD[j-1] \Big) \times p5[j] \end{aligned} \tag{3.178}$$

$$fD[(j-1) \times 5 + 2][6] = tfnp2D[6][j] \times p4[j] \tag{3.179}$$

[16] It is assumed, that does that failed to conceive are mated again only in the next reproductive cycle

- Feed requirement for does of categories $i = [(j-1)\times 5+3]$ where $j = 2,\ldots,RR-1)$ is:

$$fD[(j-1)\times 5+3][1] = fD[(j-1)\times 5+2][1] \tag{3.180}$$

$$fD[(j-1)\times 5+3][6] = tfnpc2D[6][j]\times p4[j] \tag{3.181}$$

- Feed requirement for does of categories $i = [(j-1)\times 5+5]$ where $j = 2,\ldots,RR-1)$ is:

$$\begin{aligned} fD[(j-1)\times 5+5][1] \quad = \quad & \Big((tf21D[1][j][0]+tfwpD[1][j][0]) \\ & \times(1-pcrossD[j-1]) \\ & +tfwkpD[1][j][0]\times(1-pcrossD[j]) \\ & +(tf21D[1][j][1]+tfwpD[1][j][1])\times pcrossD[j-1] \\ & +tfwkpD[1][j][1]\times pcrossD[j]\Big)\times p5[j]+ \\ & \Big((tfnkpD[1][j][0]\times(1-pcrossD[j]) \\ & +tfnkpD[1][j][1]\times pcrossD[j]\Big)\times p4[j] \end{aligned} \tag{3.182}$$

$$fD[(j-1)\times 5+5][6] = tfnkoD[6][j]\times p4[j] \tag{3.183}$$

- Feed requirement for does of categories $i = [(j-1)\times 5+4]$ where $j = 2,\ldots,RR-1)$ is:

$$\begin{aligned} fD[(j-1)\times 5+4][1] \quad = \quad & \Big((tf21D[1][j][0]+tfwpD[1][j][0]) \\ & \times(1-pcrossD[j-1]) \\ & +(tf21D[1][j][1]+tfwpD[1][j][1]) \\ & \times pcrossD[j-1]\Big)\times p5[j] \end{aligned} \tag{3.184}$$

$$fD[(j-1)\times 5+4][6] = tfwknpD[6][j]\times p5[j] \tag{3.185}$$

Feed requirement for does categories on reproductive cycles RR

In reproductive cycle RR, the feed requirement is calculated only for the category on state 2, i.e. for the category $i = [(RR-1)\times 5+2]$ as follows:

$$\begin{aligned} fD[(RR-1)\times 5+2][1] \quad = \quad & (tf21D[1][RR][0]+tfwnpD[1][RR][0]) \\ & \times(1-pcrossD[RR-1]) \\ & +(tf21D[1][RR][1]+tfwnpD[1][RR][1]) \\ & \times pcrossD[RR-1] \end{aligned} \tag{3.186}$$

Feed requirement for does died within reproductive cycle 1 to RR (does of state 1)

Feed requirement for these doe categories which belong to state 1, i. e. categories $i = [(j-1)\times 5+1]$ where $j = 1,\ldots,RR$ (see Subsection 2.2.1) are calculated as half of feed requirement of categories which belong to state 2, i.e. categories $i = [(j-1)\times 5+2]$ where $j = 1,\ldots,RR$ on the appropriate reproductive cycle. The feed requirement is covered from lactation diet (diet number 1) for does that

start a reproductive cycle with kindling or from diet number 6 (diet for open does) for does that start a reproductive cycle without kindling:

$$fD[(j-1)\times 5+1][1] = fD[(j-1)\times 5+2][1]/2.0 \tag{3.187}$$

and

$$fD[(j-1)\times 5+1][6] = fD[(j-1)\times 5+2][6]/2.0 \tag{3.188}$$

Chapter 4

Calculation of costs, revenues and profit

Total costs in a rabbitry are first calculated per doe per reproductive cycle and then converted into costs per doe per year. Total costs are divided into feeding costs and non-feed costs, the later are further differentiated in specific and non-specific non-feed costs. Specific non-feed costs are those that can be associated with specific animal (i.e. vaccination of animals, insemination of does), non-specific non-feed costs are associated with specific part of rabbitry or with animal groups (i.e depreciation of buildings, boxes and other facilities for does, fattened animals and reared replacements, overhead expenses, general labour costs).

4.1 Feeding costs for progeny categories per doe per reproductive cycle

First the feeding costs are calculated per animal of progeny category i and genotype j (where $j = 0$ designate purebred and $j = 1$ crossbred animals), ($costfP[i][j]$), and then these costs are summarised per doe per reproductive cycle by multiplying them by the vector $l1P[i][j]$ which accounts for the number of progeny of the specific category per doe in the herd (with and without kindling) and per reproductive cycle. Feeding costs include costs for feed and drinking water.

- For progeny categories $i = 1$ and $i = 2$ and genotype j, the feeding costs (in MU per animal) are zero: $costfP[1][j] = costfP[2][j] = 0.0$.
- For progeny category $i = 3$ and genotype j the feeding costs (in MU per animal) are:

$$costfP[3][j] = tfP[2][3][j] \times prfd[2] \tag{4.1}$$

- For progeny category $i = 5$ and genotype j the feeding costs (in MU per animal) are:

$$costfP[5][j] = \begin{cases} tfP[3][5][j] \times prfd[3] + \frac{waterP \times prw \times dP[5][j]}{1000} & \text{if } nff = 1 \\ tfP[3][5][j] \times prfd[3] + tfP[4][5][j] \times prfd[4] & \\ + \frac{waterP \times prw \times dP[5][j]}{1000} & \text{if } nff = 2 \end{cases} . \tag{4.2}$$

where the number 1000 convert the price of water given per cubic metre to price per litre.

- For progeny category $i = 4$ and genotype j the feeding costs (in MU per animal) are:
$$costfP[4][j] = 0.5 \times costfP[5][j] \tag{4.3}$$

- For progeny categories $i = 7, 8, 9, 10$ and genotype $j = 0$ the feeding costs (in MU per animal) are:
$$costfP[i][0] = tfP[5][i][0] \times prfd[5] + waterP \times prw \times dP[i][0]/1000 \tag{4.4}$$

- For progeny category 7 and genotype $j = 1$ the feeding costs (in MU per animal) are:
$$costfP[7][1] = tfP[5][7][1] \times prfd[5] + waterP \times prw \times dP[7][1]/1000 \tag{4.5}$$
These costs are calculated only on Production system 2 if this category exists, i.e. if pexG[1]>0.

- For progeny category $i = 6$ and genotype $j = 0$ the feeding costs (in MU per animal) are:
$$costfP[6][0] = 0.5 \times costfP[8][0] \tag{4.6}$$

- For progeny category $i = 11$ and genotype $j = 0$ the feeding costs (in MU per animal) are:
$$\begin{aligned} costfP[11][0] \quad = \quad & tfP[5][11][0] \times prfd[5] + tfP[1][11][0] \times prfd[1] \\ & + waterP \times prw \times dP[11][0]/1000 \end{aligned} \tag{4.7}$$

- For progeny category $i = 14$ (calculated only for $mtype[0] = 2$) or category $i = 15$ (calculated only for $mtype[0] = 1$) and genotype $j = 0$ the feeding costs (in MU per animal) are:
$$costfP[i][0] = \begin{cases} tfP[3][i][0] \times prfd[3] + \frac{waterP \times prw \times dP[i][0]}{1000} & \text{if } nfb = 3 \\ tfP[4][i][0] \times prfd[4] + \frac{waterP \times prw \times dP[i][0]}{1000} & \text{if } nfb = 4 \end{cases} . \tag{4.8}$$

- For progeny category $i = 16$ and genotype $j = 0$ (calculated only if $bsyst < 3$ and $pexB[0] > 0$) the feeding costs (in MU per animal) are:
$$costfP[16][0] = \begin{cases} tfP[3][16][0] \times prfd[3] + \frac{waterP \times prw \times dP[16][0]}{1000} & \text{if } nfb = 3 \\ tfP[4][16][0] \times prfd[4] + \frac{waterP \times prw \times dP[16][0]}{1000} & \text{if } nfb = 4 \end{cases} . \tag{4.9}$$

- For progeny category $i = 12$ and genotype $j = 0$ the feeding costs (in MU per animal) are:
$$costfP[12][0] = \begin{cases} 0.5 \times costfP[14][0] & \text{if } mtype[0] = 2 \\ 0.5 \times costfP[15][0] & \text{if } mtype[0] = 1 \end{cases} . \tag{4.10}$$

- For progeny category $i = 13$ and genotype $j = 0$ (calculated only for $bsyst < 3$) the feeding costs (in MU per animal) are:
$$costfP[13][0] = \begin{cases} \frac{costfP[14][0]}{dP[14][0]} \times dP[13][0] & \text{if } mtype[0] = 2 \\ 0 & \text{if } mtype[0] = 1 \end{cases} . \tag{4.11}$$

- For progeny category $i = 13$ and genotype $j = 1$ the feeding costs (in MU per animal) are assumed to be zero, because $dP[13][1] = 0$.

- Total feeding costs for progeny per doe in the herd (including does entering a cycle without kindling) per reproductive cycle ($tcfPcy$) are

$$tcfPcy = \sum_i \sum_j (costfP[i][j] \times l1P[i][j]) \tag{4.12}$$

4.2 Feeding costs for doe categories

Does are fed with feed diets $k = 1$ or $k = 6$. Therefore, a general equation for the feeding costs (including feed and drinking water, $costfD[i]$) in MU per doe of category i ($i = 1, \ldots, TD$) can be calculated as:

$$costfD[i] = fD[i][1] \times prfd[1] + fD[i][6] \times prfd[6] + \frac{waterD \times prw \times d[i]}{1000} \tag{4.13}$$

- Total feeding costs for does per doe in the herd (including does entering a cycle without kindling) per reproductive cycle ($tcfDcy$) are

$$tcfDcy = \sum_{i=1}^{TD} (costfD[i] \times l1D[i]) \tag{4.14}$$

4.3 Feeding costs for bucks used in the doe herd for natural mating

- Feeding costs per buck of genotype j (where $j = 0$ designate bucks used for purebreeding and $j = 1$ bucks used for crossbreeding),used for natural mating $costfB[j]$ are:

$$costfB[j] = tfB[i][j] \times prfd[i] + waterP \times prw \times lifenmB[j]/1000 \tag{4.15}$$

  where i is the number of diet used for bucks; $i = 3$ if the variable in input file INPUTR09.TXT $nfb = 3$ or it is $i = 4$ if $nfb = 4$.

- Total feeding costs for bucks of genotype j used for natural mating $tcfBcy[j]$ per doe in the herd (including does entering a cycle without kindling) per reproductive cycle are

$$tcfBcy = \sum_j (costfB[j] \times numnmyB[j]) \tag{4.16}$$

4.4 Non-feed costs

Input data for non-feed are located in input files INPUTR10.TXT (see Section 7.1.11). Specific and non-specific non-feed costs are distinguished. Specific non-feed costs can be assigned to specific animal category or at least to specific animal groups (e.g. veterinary treatment of does, bucks, fattened rabbits, insemination costs of does). Non-specific non-feed costs are costs that can be assigned only to housing places or to whole rabbitry (overhead costs, fuel, energy etc.). Non-feed costs are assumed to be the same for purebred and for crossbred progeny.

4.4.1 Specific non-feed costs

The following specific non-feed costs are included:

- Costs for health care (e.g. vaccination) of reproductive does

- Cost for doe insemination including costs for external worker, if AI is made as service (only if AI is applied, i.e. $mtype[j] = 1$)
- Costs for health care of young breeding does and bucks
- Costs for health care of fattened animals
- Costs for disposal of dead animal. Those cost are calculated from the weight of dead animals and costs for rendering of 1 kg weight of dead animals.
- Costs for supplies and miscellaneous which can be assigned to specific animal group (e.g. bedding material)
- Costs for marketing of fattened animals
- Costs for marketing of young breeding bucks and young does
- Costs for purchasing bucks for crossing if natural mating is applied (in Production systems 2 and 3)
- Costs for purchasing doe replacement in Production system 3

4.4.2 Non-specific non-feed costs

Non-specific non-feed costs are mainly fixed costs. Of course, from the point of view of the economic value calculation, these costs are treated as variable costs. E.g. a shorter finishing period due to improved growth rate of fattened animals causes a decrease in these fixed costs per animal. Annual fixed costs per housing place of a specific animal group should include depreciation of buildings, cages and equipment, repair costs, cost for fuel and energy, labour costs, costs for general disinfection, cleaning water, overhead costs etc. and should include empty days of bays and cages Then, those costs should be expressed per day dividing the annual fixed costs by 365.25 days (a year). Therefore, input parameters for definition of non-specific non-feed costs include fixed costs per day for each animal group (does with their litter until weaning, young breeding does and bucks, fattened animals and breeding bucks, see Section 7.1.11). Fixed costs for progeny categories 4,6, 12 and 13 and for does at states 1,2 and 3 (i.e. for animals which died or were culled) are assumed to be the same as for the appropriate animal category which stayed in the herd for the whole specific time period, the category is defined (progeny categories 5, 8 and 14 and does at state 5), because the empty cages can not be occupied with new animals until the end of the appropriate management cycle (in-and-out-cycle management is assumed).

Further non-specific non-feed costs, which should be included in fixed costs, are costs for supplies and miscellaneous which are not assigned to specific animal group.

4.4.3 Non-feed costs for progeny categories

The following equations are calculated for categories which exists in the appropriate breeding system and for the appropriate mating type; the conditions for specific equation are not always mentioned here, but they are applied in the program.

- The non-feed costs ($cnfP[i][j]$) per progeny category i ($i = 1, \ldots, 3$) and genotype j ($j = 0, 1$) are zero:

$$cnfP[1][j] = cnfP[2][j] = cnfP[3][j] = 0.0 \tag{4.17}$$

- The non-feed costs ($cnfP[i][j]$) per animal of category $i = 4, 5$ and genotype $j = 0, 1$ are calculated as:

$$cnfP[4][j] = costhfat + csupfat \times dP[4][j] + fixfat \times dP[5][j] + cdead \times wP[4][j] \quad (4.18)$$

$$cnfP[5][j] = costhfat + (csupfat + fixfat) \times dP[5][j] + cmarkf \quad (4.19)$$

- The non-feed costs ($cnfP[i][j]$) per animal of category $i = 6, \ldots, 12, 16$ and genotype $j = 0$ are calculated as:

$$\begin{aligned} cnfP[6][0] &= costhrep1D + csuprepD \times dP[6][0] \\ &\quad + fixrepD \times dP[8][0] + cdead \times wP[6][0] \end{aligned} \quad (4.20)$$

$$cnfP[7][0] = chsoldD + (csuprepD + fixrepD) \times dP[7][0] + cmarkG \quad (4.21)$$

$$cnfP[8][0] = \begin{cases} costhrep1D + costAI + (csuprepD \\ + fixrepD) \times dP[8][0] & \text{for } bsyst < 3 \\ prrepD + costAI + (csuprepD \\ + fixrepD) \times dP[8][0] & \text{for } bsyst = 3 \end{cases} . \quad (4.22)$$

$$cnfP[9][0] = costhrep2D + (csuprepD + fixrepD) \times dP[9][0] + costAI \quad (4.23)$$

$$cnfP[10][0] = csuprepD \times dP[10][0] + fixrepD \times dP[11][0] \quad (4.24)$$

$$cnfP[11][0] = (csuprepD + fixrepD) \times dP[11][0] \quad (4.25)$$

The following two equation are calculated if bsyst$<$3.

$$\begin{aligned} cnfP[12][0] &= costhrepB + csuprepB \times dP[12][0] \\ &\quad + fixrepB \times dP[14][0] + cdead \times wP[12][0] \end{aligned} \quad (4.26)$$

$$cnfP[16][0] = chsoldB + (csupsoB + fixrepB) \times dP[16][0] + cmarkB \quad (4.27)$$

- The non-feed costs ($cnfP[7][1]$) per animal of category 7 and genotype $j = 1$ are calculated as (only if $bsyst = 2$ and $pexG[1] > 0$):

$$cnfP[7][1] = chsoldD + (csuprepD + fixrepD) \times dP[7][1] + cmarkG \quad (4.28)$$

- The non-feed costs ($cnfP[i][j]$) per animal of category $i = 13, 14, 15$ and genotype $j = 0, 1$ are calculated as:

$$cnfP[13][0] = costhrepB + (csuprepB + fixrepB) \times dP[i][0] + cmarkf \quad (4.29)$$

$$cnfP[14][j] = \begin{cases} costhrepB + (csuprepB \\ + fixrepB) \times dP[14][j] & \text{for } bsyst < 3 \quad \text{and } j = 0 \\ prcrosB & \text{for } bsyst > 1 \quad \text{and } j = 1 \end{cases} . \quad (4.30)$$

$$cnfP[15][0] = costhrepB + (csuprepB + fixrepB) \times dP[15][0] + cmarkB \quad (4.31)$$

Costs for categories 13 and 14 are calculated if mtype[j]=2, for category 15 if $mtype[0] = 1$.

- Non-feed costs for all progeny categories per doe in the herd per reproductive cycle ($tcnfPcy$) are:

$$tcnfPcy = \sum_i \sum_j (cnfP[i][j] \times l1P[i][j]) \quad (4.32)$$

4.4.4 Non-feed costs for doe categories

The fixed costs for all doe categories are calculated for the whole kindling interval, i.e for the time the does on state 5 is defined ($fintD = d[5]$), because the empty cages after doe dying or culling stay generally empty until the next production cycle.

- Non-feed costs ($cnfD[i]$) for doe category i ($i = [(j-1) \times 5 + 1]$ where $j = 1, \ldots, RR$ are calculated as:

$$cnfD[i] = costhD + csupD \times d[1] + fixD \times d[5] + cdead \times wfD[i] \quad (4.33)$$

- Non-feed costs ($cnfD[i]$) for doe category i ($i = [(j-1) \times 5 + 2]$ where $j = 1, \ldots, RR$ are calculated as:

$$cnfD[i] = costhD + csupD \times d[2] + fixD \times d[5] \quad (4.34)$$

- Non-feed costs ($cnfD[i]$) for doe category i ($i = [(j-1) \times 5 + k]$ where $k = 3, 4, 5$ and $j = 1, \ldots, RR - 1$ are calculated as:

$$cnfD[i] = costhD + csupD \times d[k] + fixD \times d[5] + costAI \quad (4.35)$$

- Total non-feed costs for does per doe in the herd (including does entering a cycle without kindling) per reproductive cycle ($tcnfDcy$) are

$$tcnfDcy = \sum_{i=1}^{TD} (cnfD[i] \times l1D[i]) \quad (4.36)$$

4.4.5 Non-feed costs for bucks used in the doe herd for natural mating

- Non-feed costs per buck of genotype j (where $j = 0$ designate bucks used for purebreeding and $j = 1$ bucks used for crossbreeding), used for natural mating $cnfB[j]$, are expressed per time interval which is equal to doe reproductive cycle (kindling interval):

$$cnfB[j] = costhB + (csupB + fixB) \times fintD \quad (4.37)$$

- Total non-feed costs for bucks of genotype j used for natural mating $tcnfBcy[j]$ per doe in the herd (including does entering a cycle without kindling) per reproductive cycle are

$$tcnfBcy = \sum_{j} cnfB[j] \times numnmyB[j] \quad (4.38)$$

4.5 Total costs per doe per reproductive cycle, per fattened rabbit and per kg slaughter weight of fattened rabbits

- Total feeding costs per doe in the herd (including does entering a cycle without kindling) per reproductive cycle ($tfDcy$) are:

$$tfDcy = tcfDcy + tcfPcy + tcfBcy \quad (4.39)$$

- Total non-feed costs per doe in the herd (including does entering a cycle without kindling) per reproductive cycle ($tnfDcy$) are:

$$tnfDcy = tcnfDcy + tcnfPcy + tcnfBcy \tag{4.40}$$

- Total costs per doe in the herd (including does entering a cycle without kindling) per reproductive cycle ($tcostDcy$) are:

$$tcostDcy = tfDcy + tnfDcy \tag{4.41}$$

- The total costs per fattened animal ($tcostfP$, is than:

$$tcostfP = \frac{tcostDcy}{(l1P[5][0] + l1P[5][1])} \tag{4.42}$$

- The total costs per kg slaughter weight of fattened animals ($tckgfP$, is than:

$$tckgfP = \frac{tcostDcy}{(l1P[5][0] \times wP[5][0] + l1P[5][1] \times wP[5][1])} \tag{4.43}$$

4.6 Calculation of revenues

Input parameters for the calculation of revenues are given in input file INPUTR11.TXT. The revenues in the rabbit production system include the following items:

- Revenues from culled does
- Revenues from fattened animals and culled bucks
- Revenues from selling of breeding does and bucks;
- Revenues from rabbit skins
- Revenues from manure

It is expected that revenues from slaughtered and culled animals depend on the weight of animals (live weight or carcass weight) and on the market price per kg. Therefore, the following pricing systems are distinguished for culled does, bucks and fattened rabbits:

- Pricing system for culled young replacement does and reproductive does ($prcD$):
  - 1: The price is given per kg live weight (LW) of does
  - 2: The price is given per kg carcass weight (CW) of does
  - 3: Culled does can not be sold for slaughter because of hormonal treatment (costs for disposal of culled does are calculated and the revenues from culled does have a negative value)
- Pricing system for fattened animals and culled bucks[1] ($prfP$):
  - 1: The price is given per kg live weight (LW)
  - 2: The price is given per kg carcass weight (CW)

[1] All three pricing systems are assumed only for young breeding bucks (progeny category 13). For old bucks used for natural mating, only pricing systems 1 or 2 are assumed. If pricing system 3 is chosen for slaughtered animals, the program automatically used the pricing system 2 for old culled bucks.

– 3: The price is given per kg fore, mid and hind parts of carcasses

It is further expected that the price for breeding animals sold or purchased are given per animal. The following equations are applied when calculating revenues:

- Revenues per culled doe ($revD[i]$) of category i were ($i = [(j-1) \times 5 + k]$, where $k = 2$ for $j = 1, \ldots, RR$ and $k = 3$ for $j = 1, \ldots, RR - 1$ are:

$$revcD[(j-1) \times 5 + k] = \begin{cases} prbcD \times wcD[j] & \text{if } prcD = 1 \\ prbcD \times wcD[j] \times dressD/100 & \text{if } prcD = 2 \\ -cdead \times wcD[j] & \text{if } prcD = 3 \end{cases} \tag{4.44}$$

- Revenues per culled buck of genotype j ($j = 0$ for bucks of the same genotype as does and $j = 1$ for bucks of different genotype as does) used for natural mating ($revcB[j]$) are:

$$revcB[j] = \begin{cases} prbfP \times wmB[j] & \text{if } prfP = 1 \\ prbfP \times wmB[j] \times dressR[j]/100 & \text{if } prfP = 2, 3 \end{cases} \tag{4.45}$$

- Revenues per progeny category i and genotype j ($j = 0, 1$) ($revP[i]$) are calculated as:

$$revP[i][j] = \begin{cases} prbfP \times wP[i][j] & \text{for } i = 5 \quad \text{if } prfP = 1 \\ prbfP \times wP[i][j] \times dressR[j]/100 & \text{for } i = 5 \quad \text{if } prfP = 2 \\ wP[i][j] \times dressR[j]/100 \times prefc[j]/100 & \\ \times(forep[j] \times prfore + midp[j] \times prmid & \\ +hindp[j] \times prhind)/100 & \text{for } i = 5 \quad \text{if } prfP = 3 \\ prG[j] & \text{for } i = 7 \\ prbcD \times wP[i][0] & \text{for } i = 10 \quad \text{if } prcD = 1 \\ prbcD \times wP[i][0] \times dressD/100 & \text{for } i = 10 \quad \text{if } prcD = 2 \\ -cdead \times wP[i][0] & \text{for } i = 10 \quad \text{if } prcD = 3 \\ prbfP \times wP[i][0] & \text{for } i = 13 \quad \text{if } prfP = 1 \\ prbfP \times wP[i][0] \times dressR[0]/100 & \text{for } i = 13 \quad \text{if } prfP = 2 \\ wP[i][j] \times dressR[j]/100 \times prefc[j]/100 & \\ \times(forep[j] \times prfore + midp[j] \times prmid & \\ +hindp[j] \times prhind)/100 & \text{for } i = 13 \quad \text{if } prfP = 3 \\ prAIB & \text{for } i = 15 \quad \text{and } j = 0 \\ prB & \text{for } i = 16 \quad \text{and } j = 0 \end{cases} \tag{4.46}$$

Revenues for categories of does and progeny, that are not included in the above equations, are zeros.

- Revenues for culled does per doe in the herd (including does entering a cycle without kindling) per reproductive cycle ($revDcy$) are

$$revDcy = \sum_{i=1}^{TD} (revcD[i] \times l1D[i]) \tag{4.47}$$

- Revenues for all progeny categories per doe in the herd per reproductive cycle ($revPcy$) are:

$$revPcy = \sum_{i} \sum_{j} (revP[i][j] \times l1P[i][j]) \tag{4.48}$$

- Revenues for culled bucks that was used for natural mating $revBcy$ per doe in the herd (including does entering a cycle without kindling) per reproductive cycle are:

$$revBcy = \sum_j (revcB[j] \times numnmyB[j]) \tag{4.49}$$

- Revenues for skin of culled progeny per doe in the herd per reproductive cycle ($rskinPcy$) are:

$$rskinPcy = prskin \times wskin \times \Big(\sum_j (l1P[5][j]) + l1P[10][0] + l1P[13][0] \Big) \tag{4.50}$$

- Revenues for skin of culled does per doe in the herd per reproductive cycle ($rskinDcy$) are:

$$rskinDcy = prskin \times wskin \times \sum_i (l1D[i]) \tag{4.51}$$

where $(i = [(j-1) \times 5 + 2]$ for $j = 1, \ldots, RR-1$ and $(i = [(j-1) \times 5 + 3]$ for $j = 1, \ldots, RR-2$

- Revenues for skin of culled bucks that was used for natural mating $rskinBcy$ per doe in the herd (including does entering a cycle without kindling) per reproductive cycle are:

$$rskinBcy = prskin \times wskin \times \sum_j numnmyB[j] \tag{4.52}$$

- Revenues for manure of progeny in fattening per doe in the herd per reproductive cycle ($rmanfPcy$) are:

$$rmanfPcy = wmanfP \times prmanure \times \Big(\sum_j (l1P[5][j]) \times dP[5][j] \Big) / 100 \tag{4.53}$$

where the number 100 converts the price of manure given per 100 kg to price of manure per kg.

- Revenues for manure of replacement progeny in rearing per doe in the herd per reproductive cycle ($rmanrPcy$) are:

$$rmanrPcy = wmanrP \times prmanure \times \Big(\sum_j (l1P[i][0]) \times dP[i][0] \Big) / 100 \tag{4.54}$$

where $i = 6, \ldots, 16$

- Revenues for manure of does per doe in the herd per reproductive cycle ($rmanDcy$) are:

$$rmanDcy = wmanD \times prmanure \times \sum_i (l1D[i] \times d[i]) / 100 \tag{4.55}$$

where $(i = 1, \ldots, TD$

- Revenues for manure of bucks used for natural mating $rmanBcy$ per doe in the herd (including does entering a cycle without kindling) per reproductive cycle are:

$$rmanBcy = wmanB \times prmanure \times \sum_j numnmyB[j] \times fintD / 100 \tag{4.56}$$

- Total revenues per doe in the herd (including does entering a cycle without kindling) per reproductive cycle ($trevDcy$) are:

$$\begin{aligned} trevDcy &= revDcy + revPcy + revBcy + rskinPcy + rskinDcy + rskinBcy \\ &\quad + rmanfPcy + rmamrPcy + rmanDcy + rmanBcy \end{aligned} \tag{4.57}$$

- The total revenues per fattened animal ($trevfP$, is than:

$$trevfP = \frac{trevDcy}{(l1P[5][0] + l1P[5][1])} \tag{4.58}$$

- The total revenues per kg slaughter weight of fattened animals ($trkgfP$, is than:

$$trkgfP = \frac{trevDcy}{(l1P[5][0] \times wP[5][0] + l1P[5][1] \times wP[5][1])} \tag{4.59}$$

4.7 Calculation of profit and profitability

Total profits per doe per reproductive cycle and per year are calculated as the differences between total revenues and total costs for the appropriate period. The profit is further expressed per fattened animal and per kg of slaughter weight of fattened animals. Profitability is defined as profit per unit of costs and is expressed in per cent. The following calculations are done:

- The number of doe reproductive cycles per year ($ncyD$) is:

$$ncyD = \frac{365.25}{fintD} \tag{4.60}$$

- The total revenues per doe per year ($trevDy$) are

$$trevDy = trevDcy \times ncyD \tag{4.61}$$

- The total costs per doe per year ($costDy$) are

$$tcostDy = tcostDcy \times ncyD \tag{4.62}$$

- The total profit per doe per reproductive cycle ($Tprofcy$) is:

$$Tprofcy = trevDcy - tcostDcy \tag{4.63}$$

- The total profit per doe per year ($Tprof$) is:

$$Tprof = Tprofcy \times ncyD \tag{4.64}$$

- The total profit per fattened animal ($TproffP$) is than:

$$Tproff = \frac{Tprofcy}{(l1P[5][0] + l1P[5][1])} \tag{4.65}$$

- The total profit per kg slaughter weight of fattened animals ($TprofkgfP$) is than:

$$TprofkgfP = \frac{Tprofcy}{(l1P[5][0] \times wP[5][0] + l1P[5][1] \times wP[5][1])} \tag{4.66}$$

- The profitability (%) of the rabbit production system ($prof$) is:

$$prof = 100 \times \frac{Tprofcy}{tcostDcy} \tag{4.67}$$

Chapter 5

Marginal economic values and economic weights

5.1 General principles for the calculation of economic values of traits

The *marginal economic value* is generally defined as the partial derivative of the profit function with respect to the trait considered [3]. It is expressed per given unit of the trait, per specified base and per time interval. In our model, the marginal economic values are given per unit of the trait, per doe (including does with and without kindling) and per year. A fixed number of does in the evaluated population is assumed when changing the trait means. When using complex bio-economic models (as in the present program) instead of simple profit functions, the exact partial derivative must be replaced by an approximate method, i.e. by a numeric derivative (difference quotient). The profit on which the estimation of economic values is based is calculated for the whole production system of the given breed or breed combination. All traits considered show continuous variation so that the general procedure for the calculation of economic values is equal for all traits.

The numeric derivative of the profit function with respect to the considered trait is calculated by increasing and decreasing the average value of the trait TV_{av} by 0.5%. Let TV_h be the higher value of the trait considered which was derived as $TV_h = 1.005TV_{av}$. Similarly, TV_l is calculated by decreasing the average trait value by the same proportion: $TV_l = 0.995TV_{av}$. Furthermore, let TP_h and TP_l be the total profit belonging to the first or the second of these values, respectively. The partial derivative is then approximated by the following difference quotient:

$$ev = \frac{TP_h - TP_l}{TV_h - TV_l} \ . \tag{5.1}$$

The marginal economic value is expressed in monetary units (MU) per unit of the trait per doe and year. The marginal economic value of a trait quantifies, therefore, the change in the total profit per doe per year in a production system of a breed or crossbreed. A survey on the variables which are changed when calculating the economic values of evaluated traits is given in Table 5.1 .

Calculation of economic values if there is crossbreeding

In the case of two progeny types in the evaluated population (i.e. purebred and crossbred progeny), the trait level is increased (decreased) separately for both progeny types and two economic values are calculated for each trait that is handled

Table 5.1: Variables changed in the calculation of economic values of traits. The number of the trait according to Appendix A is given in parentheses.

Trait in the denominator of Eq. 5.1	Variable(s) changed
Conception rate of young does at first mating, $con1G$ (1)	$con1G$, $con2G$
Conception rate of does at first mating averaged over all reproductive cycles, $conrateD0$ (2)	$conrateD[i]$, $i = 1, \ldots, RR-1$
Number of kits born total averaged over all reproductive cycles, $nbt[0] + nbt[1]$ (3)	$nb[i][j]$, $i = 1, \ldots, RR$, $j = 0, 1$
Number of kits born alive per litter averaged over all reproductive cycles, $nbat[0] + nbat[1]$ (4)	$nba[i][j]$, $i = 1, \ldots, RR$, $j = 0, 1$
Number of kits weaned averaged over all reproductive cycles, $nwt[0] + nwt[1]$ (5)	$nw[i][j]$, $i = 1, \ldots, RR$, $j = 0, 1$
Percentage of stillborn kits per litre averaged over all reproductive cycles, $pstill0$ (6)	$nba[i][j]$, $nw[i][j]$ $i = 1, \ldots, RR$, $j = 0, 1$
Survival rate of kits until weaning averaged over all reproductive cycles, $surbw0$ (7)	$nw[i][j]$, $i = 1, \ldots, RR$, $j = 0, 1$
Litter weight at 21 d of kits' age, $lw21$ (8)	$w21[j]$, $j = 0, 1$
Doe mortality rate in per cent averaged over all reproductive cycles, $pdiedD0 * 100$ (9)	$pdfwD[i]$, $i = 1, \ldots, RR$,
Productive lifetime of does in number of reproductive cycles, $pltnfD$ (10)	$pdfwD[i]$, $i = 1, \ldots, RR$,
Productive lifetime of does in years, $pltyD$ (11)	$pdfwD[i]$, $i = 1, \ldots, RR$,
Survival rate of rabbits in fattening, $srfP[j]$ (12)	$pdiedfP[j]$, $j = 0, 1$,
Litter weight at weaning, $avlw[j]$ (13)	$wP[3][j]$, $j = 0, 1$,
Daily gain of kits between the 21th day of age and weaning, $adg21w$ (14)	$wP[3][j]$, $j = 0, 1$,
Daily gain in fatening, $adgP[5][j]$ (15)	$adgP[5][j]$, $j = 0, 1$,
Residual feed intake during whole fattening period $tfP[3][5][j] + tfP[4][5][j]$, (16)	$rfiP[3][5][j]$, $rfiP[4][5][j]$, $j = 0, 1$,
Feed conversion ratio during fattening, $fconv[j]$ (17)	$fP[3][5][j]$, $fP[4][5][j]$, $j = 0, 1$,
Dressing percentage of slaughtered rabbits, $dressR[j]$ (18)	$dressR[j]$ $j = 0, 1$,
Percentage of hind part in the reference carcass[a]of fattened rabbits, $hindp[j]$ (19)	$hindp[j]$ $j = 0, 1$,
Percentage of valuable parts (mid and hind parts) in reference carcass of fattened rabbits, $valp[j]$ (20)	$midp[j]$, $hindp[j]$ $j = 0, 1$,

[a]Reference carcass were defined as chilled carcass without head, set of organs, liver and kidneys and included the meat, bones and fat depots (see [6]).

as progeny trait: an economic value for trait i expressed in the purebred progeny of the breed ($ev[i][0]$) and an economic value for trait i expressed in the crossbred progeny ($ev[i][1]$). ***More generally speaking, index 0 refers to the same genotype as the genotype of the does. For example, in the calculation for the crossbreed AB in Production System 3, index 0 refers to animals of genotype AB (doe traits) and index 1 refers to animals of genotype AB x C (crossbred progeny traits).***

5.2 Definition of traits and assumption for the calculation of their economic values

Generally, four groups of traits are of interest in rabbits: functional traits (reproduction and health), growth traits, feed efficiency traits, and carcass traits.

5.2.1 Functional traits (reproduction and survival)

The following reproductive traits can be evaluated (the number of the trait in the program is given in parentheses, see also Appendix A):

- Conception rate of young does at first mating (i.e. conception rate of female replacement before 1st kindling, 1)
- Conception rate of does at first mating averaged over all parities 1 to RR-1 (2)
- Total number of kits born per litter averaged over parities and litter genotypes (3, TNB)[1]
- Number of kits born alive per litter averaged over parities and litter genotypes (4, NBA, alternative trait to TNB)
- Number of kits weaned per litter averaged over parities and litter genotypes (5, NW, alternative trait to TNB or to NBA)
- Still born rate (percentage of stillborn kits per litter averaged over parities and litter genotypes) (6)
- Survival rate of kits born alive until weaning per litter averaged over parities and litter genotypes (7)
- Litter weight at 21th day of kit age averaged over parities and litter genotypes (8)

All these reproductive traits are considered to be doe traits so that no separate economic values for purebred and for crossbred litters or matings are calculated, the economic value of these traits have the second index 0 and include the effect of a change in the appropriate traits using purebred as well as crossbred matings (for conception rates) and in purebred as well as crossbred litters (litter traits). The appropriate trait values are changed proportionally for purebred and crossbred matings or purebred and crossbred litters.

Further survival traits can be evaluated:

- Mortality rate of does averaged over all parities (9)

[1] A strong interdependence between TNB, NBA and NW is assumed (for details see Subsection 5.2.1.2 on the following page) so that it should be reasonable to use only one of these three traits in a selection index simultaneously.

- Doe productive lifetime expressed in years (10)
- Doe productive lifetime expressed in number of reproductive cycles (11)
- Survival rate of rabbits in fattening (12)

5.2.1.1 Conception rates (traits 1 and 2)

General comments. Conception rate of young replacement does and does after first kindlings are assumed to be different traits. Therefore, both of those conception rates are evaluated separately when estimating the marginal economic value of the doe ability to conceive. Calculating the economic values, conception rate is handled as female trait, independent of the buck breed used for mating.

Calculating the economic values for trait 1, conception rates at first and, if exists, at second matings (variables $con1G$ and $con2G$) are changed proportionally. The economic values of trait 1 is expressed as change of profit divided by the change of the conception rate at first mating ($con1G$, reference trait[2]). Calculating the economic values for trait 2, the variables $conrateD[i]$ $(i = 1, \ldots, RR - 1)$ are proportionally changed. The new values of the variable $conrateD0$, is calculated according to Eq. (2.27). The economic values of trait 2 is expressed as change of profit divided by the change of the variable $conrateD0$ (reference trait).

5.2.1.2 Litter size traits TNB, NBA and NW (traits 3 to 5)

It is assumed that a change in one of the 3 traits will cause proportional changes in the 2 remaining litter size traits. When calculating the economic value of any one of the litter size traits, the variables $nb[i][j]$, $nba[i][j]$ and $nw[i][j]$ $(i = 1, \ldots, RR$ is the number of the reproductive cycle, $j = 0, 1$ refers to purebred and crossbred litters, respectively) are changed with the same proportion. The economic value is then expressed as change of profit divided by the change in the following reference traits:

- the average total number of kits born ($nbt0 = nbt[0] + nbt[1]$ for TNB, trait 3),
- the average number of kits born alive ($nbat0 = nbat[0] + nbat[1]$ for NBA, trait 4) or
- the average number of kits weaned (nwt0=$nwt[0] + nwt[1]$ for NW, trait 5).

This procedure ensures that survival rates for kits are kept constant, because the survival traits are evaluated separately.

5.2.1.3 Stillborn rate and survival rates for kits (traits 6 and 7)

Percentage of stillborn kits (traits 6) is handled as doe trait. Therefore, calculating the economic value for this trait, the percentage of stillborn kits in purebred and crossbred litters is changed simultaneously changing the values of $nba[i][j]$ while keeping the values of $nb[i][j]$ constant and changing the values of $nw[i][j]$ in such a way that the survival rate of kits until weaning remains constant. The reference trait (the trait in the denominator of Eq. (5.1)) for the calculation of the economic weight is the percentage of stillborn kits (%) averaged over genotypes of kits and over reproductive cycles ($pstill0$):

$$pstill0 = 100 \times \frac{nbat[0] + nbat[1]}{nbt[0] + nbt[1]} \ . \tag{5.2}$$

[2] A reference trait is defined as the trait per unit of which the marginal economic value is expressed

Survival rate of kits born alive until weaning ($surbw[j]$, in %) for kits of genotype j ($j = 0$: purebred litters, $j = 1$: crossbred litters) averaged over all reproductive cycles is as given in Eq. (2.64). Calculating the economic value for survival rate until weaning (trait 7), the values of $nw[i][j]$ are changed while keeping the values of $nb[i][j]$ and $nba[i][j]$ constant. The reference trait for the calculation of the economic weight is the survival rate (%) until weaning averaged over genotypes of kits and over reproductive cycles ($surbw0$):

$$surbw0 = 100 \times \frac{nwt[0] + nwt[1]}{nbat[0] + nbat[1]} \; . \tag{5.3}$$

That means that this traits is handled again as doe trait.

5.2.1.4 Litter weight at 21th day of kit age averaged over parities and litter genotype (trait 8)

Litter weight at 21th day of kit age is also handled as a doe trait which characterise the doe ability for milk production. The economic value of this trait has the second index 0 and includes the effect of a change in the weight of purebred as well as crossbred litters.

First, the litter weight at 21th day of kit age ($lw21$) averaged over parities and litter genotypes is calculated as:

$$\begin{aligned} lw21 \quad = \quad & \Big(\sum_{i=1}^{RR} nba[i][0] \times w21[0] \times l3D[i] \times (1 - pcrossD[i-1]) \\ & + \sum_{i=1}^{RR} nba[i][1] \times w21[1] \times l3D[i] \times pcrossD[i-1] \Big) \Big/ \sum_{i=1}^{RR} l3D[i] \end{aligned} \tag{5.4}$$

Calculating the economic value for average litter weight at 21 days of age (trait 8), the input variables $w21[j]$ are changed proportionally for purebred litter (second index $j = 0$) and for crosbred litters ($j = 1$) keeping the weight of kits at birth constant. The new values of the variable ($lw21$) are then calculated and inserted in the denominator of Eq. (5.1).

5.2.1.5 Mortality rate and productive lifetime of does (traits 9, 10 and 11)

Doe mortality rates (does died within a reproductive cycle) in all reproductive cycles (variables $pdfwD[i]$, $i = 1, \ldots, RR$) were changed calculating economic values for the trait doe mortality rate or for the alternative traits to that trait doe productive lifetime in number of years or in number of reproductive cycles. The new values of the average doe mortality rate ($pdiedD0$) or the new values of the doe productive lifetime in number of years ($pltyD$) or in number of reproductive cycles ($pltnfD$) were than calculated as given in Eq. (2.37) (2.33) or (2.34), respectively. The economic values of traits 9, 10 and 11 are than expressed as change of profit divided by the change of $pdiedD0$ (trait 9), $pltyD$ (trait 10) or $pltnfD$ (trait 11).

5.2.1.6 Survival rate of young rabbits in fattening (trait 12)

Separate marginal economic values are calculated for purebred and for crossbred animals. Calculating the economic values, the variables $pdiedfP[j]$, are changed where $j = 0$ is used for purebred and $j = 1$ for crossbred animals in fattening. This results in appropriate changes in the survival rates $srfP[j]$ (see Eq. 2.65). At the same time, the survival rates of kits from birth to weaning and survival rates of adult animals and replacements are kept constant.

5.2.2 Growth traits (traits 13, 14 and 15)

In our model, the growth pattern of rabbits is approximated by a multi-phase growth curve assuming linear functions for the individual phases of growth (see Chapter 3).

The traits for different growth phases of young animals are evaluated and treated as progeny traits. Therefore the economic values are calculated separately for purebred ($j = 0$) and crossbred ($j = 1$) progeny (the number of the trait in the program is given in parentheses, see also Appendix A). The following traits are differentiated:

- Daily gain of kits between the 21th day of age and weaning, $adg21w[j]$ (13) is calculated as:

$$adg21w[j] = 1000 \times (wP[3][j] - w21[j])/(agew - 21) \; . \tag{5.5}$$

- Litter weight at weaning averaged over all parities, $avlw[j]$ (14, alternative trait to daily gain) is:

$$avlw[j] = wP[3][j] \times avnw[j] \; . \tag{5.6}$$

  where the variable $avnw$ is the average number of weaned kits per purebred ($j = 0$) and crossbred litter ($j = 1$) which is calculated as:

$$\begin{aligned} avnw[0] &= \frac{\sum_{i=1}^{RR} nw[i][0] \times l3D[i] \times (1 - pcrossD[i-1]}{\sum_{i=1}^{RR} l3D[i] \times (1 - pcrossD[i-1]} \\ avnw[1] &= \frac{\sum_{i=1}^{RR} nw[i][1] \times l3D[i] \times pcrossD[i-1]}{\sum_{i=1}^{RR} l3D[i] \times pcrossD[i-1]} \end{aligned} \tag{5.7}$$

- Average daily gain of rabbits in fattening to fixed target slaughter weight, $adgP[5][j]$ (15)

Calculating the economic values for average daily gain of kits from 21th day until weaning (trait 13), or alternatively for litter weight at weaning (14) the variable $wP[3][j]$ is changed ($j = 0$: purebred kits, $j = 1$: crossbred kits) keeping the kit weight at 21th day of age (that means the litter weight at 21th day of kit age) constant. Calculating the economic value for the average daily gain of rabbits in fattening (trait 15) the variable $adgP[5][j]$ is change keeping the weight of kits at weaning and target slaughter weight constant. That means, the length of fattening period changes.

5.2.3 Feed efficiency traits (traits 16 and 17)

The following feed efficiency traits can be evaluated (the number of the trait in the program is given in parentheses, see also Appendix A):

- Residual feed intake in fattening given in kg fresh feed matter in the whole fattening period $rfiP[j]$ (16)
- Feed conversion in fattening (17, alternative trait to residual feed intake in fattening)

Residual feed intake measures whether an animal eats more or less feed than predicted by published feeding standards in dependency on protein and fat deposition or by comparison with measured feed intakes of like-type animals (e.g., same breed, sex, age) eating the same feed [1]. That means, the residual feed intake is the difference between the actual and the predicted feed intake. In the program, the

predicted feed intakes for the defined animal categories are calculated on the basis of actual growth data for the specific animal group and on the chemical composition of empty body gain of growing rabbits published in the literature (see [13] and Section 3.4). The average feed intake is then assumed to be equal to the predicted feed intake so that the average residual feed intake is assumed to be zero for all animal groups. Only the residual feed intake for rabbits in fattening is evaluated [7] ($rfiP[k][i][j] = 0$). In the calculation of economic values for the residual feed intake in fattening, the daily residual feed intakes of diets number 3 and 4 are set to the values which are equal to $\pm 0.5\%$ of the daily feed intake of diets numbers 3 and 4. Then the total feed intake during fattening ($fP[3][5][j]$ and $fP[4][5][j]$) is calculated, separately for purebred ($j = 0$) and for crossbred ($j = 1$) progeny. The change in the sum of $tfP[3][5][j] + tfP[4][5][j]$, i.e. in the total feed intake during fattening, is then used as denominator in Eq. 5.1. **Feed conversion** in fattening ($fconv$) is defined as the average amount of fresh feed matter intake in kg needed per kg gain of body weight:

$$fconv = (tfP[3][5][j] + tfP[4][5][j])/(wP[5][j] - wP[3][j]) \ , \tag{5.8}$$

where $j = 0, 1$. The change in the value of $fconv$ caused by the change of the daily feed intake in fattening is inserted as the denominator in Eq. 5.1 when calculating economic value of feed conversion.

5.2.4 Carcass traits (traits 18, 19 and 20)

The following carcass traits can be evaluated (the number of the trait in the program is given in parentheses, see also Appendix A):

- Dressing percentage, $dressR[j]$ (18)
- Percentage of hind part in the reference carcass of fattened rabbits, $hindp[j]$ (19)
- Percentage of valuable parts (mid and hind parts) in reference carcass of fattened rabbits, $valp[j]$ (20, alternative trait to trait 19) calculated as:

$$valp[j] = midp[j] + hindp[j] \ , \tag{5.9}$$

Dressing percentage can be evaluated only if slaughtered animals are paid according to carcass weight (if $prfP = 2, 3$), the economic values for the percentage of hind part or of valuable (hind and mid) parts are calculated only if slaughtered animals are valuated according to the amount of valuable parts of rabbit carcasses (if $prfP = 3$). Carcass traits are of interest only in fattened animals so that only the purebred and crossbred progeny of category 5 is taken into account in the calculation.

Calculating the economic value for dressing percentage, the value of the variable $dressR[j]$ is changed separately for purebred progeny ($j = 0$) and for crossbred progeny ($j = 1$).

Calculating the economic value for the percentage of hind part, the value of $hindp[j]$ is increased and decreased keeping the percentage of fore and mid part constant. That means that changing the percentage of hind part, a change in the amount of fat depots in reference carcass is assumed.

Calculating the economic value for the percentage of valuable parts, both values $hindp[j]$ and $midp[j]$ are proportionally changed keeping the percentage of fore part constant. That means again that changing the percentage of the valuable parts (mid and hind parts), a change in the amount of fat depots in reference carcass is assumed. These values are changed separately for purebred progeny ($j = 0$) and for crossbred progeny ($j = 1$).

5.3 Absolute, standardised and relative economic weights

Economic weights of trait i for specific breed combine the marginal economic values for this trait expressed in purebred ($j = 0$) and crossbred ($j = 1$) progeny according to the proportion of genes of this breed in those progeny. Only one generation of progeny is taken into account in these economic weights. Furthermore, because of a short doe reproductive cycle, the different time when a trait influences revenues and costs in rabbit production systems is not taken into account (no discounting is applied).

The economic weights are calculated only for traits selected on the basis of INPUTR12.TXT and for traits for that no alternative traits exist.

Absolute economic weights for all traits (traits 1 to 20)

The absolute economic weights for traits are calculated for the doe breed in Production systems 1 or 2 ($evp[i]$), for both dam breeds used for production of crossbred doe replacement for Production system 3 ($evmp[i]$) and for sires of breed used for terminal crossing in Production systems 2 or 3 ($evsp[i]$). The following equations are needed:

- In Production system 1 with only purebred progeny, it holds simply

$$evp[i] = ev[i][0] \ . \tag{5.10}$$

  for progeny as well as for doe traits. The same equation holds also for doe breed economic weights for doe traits in Production system 2.

- In Production systems 2, the doe breed economic weights for progeny traits contain two components:

$$evp[i] = ev[i][0] + 0.5 \times ev[i][1] \ . \tag{5.11}$$

- For the two dam breeds used for production of crossbred doe replacement for Production system 3, the economic weights are calculated as:

$$evmp[i] = 0.5 \times ev[i][0] + 0.25 \times ev[i][1] \ . \tag{5.12}$$

- Economic weights for sires of breed used for terminal crossing in Production systems 2 and 3 exist only for progeny traits and are calculated as:

$$evsp[i] = 0.5 \times ev[i][1] \ . \tag{5.13}$$

Standardised economic weights

The absolute economic weights 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 economic weight ($evst[i]$) for trait i is calculated as a product of the absolute economic weight of trait i and the genetic standard deviation of that trait in the appropriate breed. The standardised economic weights are given in monetary units per standard deviation of the trait and per doe and year. Standardised economic weights are calculated only for breeds, but not for crosses, therefore, they are calculated for doe breed in Production systems 1 and 2, for the two maternal breeds producing crossbred doe replacement for Production system 3 and for sires of breeds used for terminal crossing in Production systems 2 or 3. Standardised (and

relative) economic weights of traits are calculated only if the indicator variables for genetic standard deviations in file PARAR.TXT are equal to 1 and if the genetic standard deviations for the traits selected in INPUTR12.TXT and for traits with no alternative expressions are given in input files 13 to 16 (see Subsections 7.1.14 to 7.1.17).

- For the breed of does in Production systems 1 or 2, the standardised economic weight of trait i ($evst[i]$) is calculated as:

$$evst[i] = evp[i] \times gsd\_d[i] \ . \tag{5.14}$$

- For the dam breed used in dam position to produce crossbred doe replacement for Production system 3, the standardised economic weight of trait i ($evstm1[i]$) is calculated as:

$$evstm1[i] = evmp[i] \times gsd\_dm1[i] \ . \tag{5.15}$$

- For the dam breed used in sire position to produce crossbred doe replacement for Production system 3, the standardised economic weight of trait i ($evstm2[i]$) is calculated as:

$$evstm2[i] = evmp[i] \times gsd\_dm2[i] \ . \tag{5.16}$$

- For sires of breeds used for terminal crossing in Production systems 2 or 3, the standardised economic weight of trait i ($evsts[i]$) is calculated as:

$$evsts[i] = evsp[i] \times gsd\_d2[i] \ . \tag{5.17}$$

Relative economic weights

As the standardised economic weights have the same unit for all traits, they can be expressed as percentage of the sum of all standardised economic weights. As both positive and negative values occur it is useful to calculate the sum from the absolute values[3] of the standardised economic weights.

- For the breed of does in Production systems 1 or 2, the sum of the standardised economic weight of traits ($sevst$) is calculated as:

$$sevst = \sum_{i \epsilon \Omega} \text{abs}(evst[i]) \tag{5.18}$$

  where Ω is the set of selected traits and the relative economic weight ($evr[i]$) for trait i is calculated as:

$$evr[i] = 100 \times \frac{\text{abs}(evst[i])}{sevst} \ . \tag{5.19}$$

- For the dam breed used in dam position to produce crossbred doe replacement for Production system 3, the sum of the standardised economic weight of traits ($sevstm1$) is calculated as:

$$sevstm1 = \sum_{i \epsilon \Omega} \text{abs}(evstm1[i]) \tag{5.20}$$

  where Ω is as above and the relative economic weight ($evrm1[i]$) for trait i is calculated as:

$$evrm1[i] = 100 \times \frac{\text{abs}(evstm1[i])}{sevstm1} \ . \tag{5.21}$$

[3] The function $\text{abs}(x)$ is defined in the following way:

$$\text{abs}(x) = \begin{cases} x & \text{if} \quad x \geq 0 \\ -x & \text{if} \quad x < 0 \end{cases} \ .$$

- For the dam breed used in sire position to produce crossbred doe replacement for Production system 3, the sum of the standardised economic weight of traits ($sevstm2$) is calculated as:

$$sevstm2 = \sum_{i \epsilon \Omega} \text{abs}(evstm2[i]) \tag{5.22}$$

where Ω is as above and the relative economic weight ($evrm2[i]$) for trait i is calculated as:

$$evrm2[i] = 100 \times \frac{\text{abs}(evstm2[i])}{sevstm2} \ . \tag{5.23}$$

- For sires of breeds used for terminal crossing in Production systems 2 or 3, the sum of the standardised economic weight of traits ($sevsts$) is calculated as:

$$sevsts = \sum_{i \epsilon \Omega} \text{abs}(evsts[i]) \tag{5.24}$$

where Ω is as above and the relative economic weight ($evrm1[i]$) for trait i is calculated as:

$$evrs[i] = 100 \times \frac{\text{abs}(evsts[i])}{sevsts} \ . \tag{5.25}$$

Chapter 6

Installing and running the program

In the given version of the program, files for running the program under LINUX and WINDOWS are given.

6.1 List of files in the installation package

6.1.1 Directory DOC

This directory contains the manual of the program for rabbits, Ewrab-2_0_1.pdf.

6.1.2 Directory SRC

This directory contains the source code of the program for rabbits, ewrab-2.0.0.c in the program language C.

6.1.3 Directories BS1, BS2 and BS3

These directories contain all files necessary for running the program EWRAB for Production Systems 1, 2 or 3.

ewrab-2.0.0 Executable file for program EWRAB version 2.0.1.

TEXTR_OUT.TXT This file contains text for writing the results for the program EWRAB. See also Section 7.2.

PARAR.TXT Parameter file which contains the most important parameters for running the program EWRAB (see Section 7.1.1).

INPUTR#.TXT with # = 01, 02, ...,16 Data input files for program EWRAB (see Section 7).

6.2 Installation under LINUX

Version 2.0.1 of program EWRAB come to you as a compressed tar-file with the name EWRAB2_0_1.tgz. Copy this file to a directory of your choice and enter the command

tar xvf EWRAB2_0_1.tgz
for uncompressing and unarchiving the file. You will get the file structure as described in Subsection 6.1.

Only for experts in programming. If you want to do changes in the program (source code) by yourself, then you must use the option -lm for compiling the source code when using the compiler gcc because otherwise the mathematical functions would not work; e.g.

gcc -o ewrab-2.0.1 ewrab-2.0.1.c -lm (in more recent versions of LINUX) or
gcc -lm -o ewrab-2.0.1 ewrab-2.0.1.c (in older versions of LINUX)
will compile the source file ewrab-2.0.1.c to the executable file ewrab-2.0.1.

6.3 Running the program under LINUX

You are recommended to create one directory for each calculation where you will copy and edit all files you will need. Then edit the parameter files PARAR.TXT (see Subsection 7.1.1) and all data input files INPUTR#.TXT (see Subsections 7.1.2 to 7.1.14). Type just ./ewrab-2.0.1 in this directory, press the ENTER button and the program will do the rest for you.

6.4 General remarks

Several checks of input parameters are included in the program. 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 to correct 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.

You are **recommended to start the program in the command line modus** because otherwise it might happen that error messages are hidden and you will not understand why the program behaves in a strange way. So be sure to see what the program is doing and use the command line modus.

6.5 Installation under Microsoft Windows

The Windows version of the program is distributed as zip file. It contains the compiled program. The program was compiled under Cygwin (http:// www.cygwin.com) and run only in the presence of the le cygwin1. dll which is part of the Windows distribution. 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 calculations should be carried out. Cygwin is freely available (install Cygwin with gcc compiler). When compiling the source code, omit the option -lm: gcc -o ewrab-2.0.1 ewrab-2.0.1.c. The versions of the program EWRAB was tested only for Microsoft Windows 7.

6.6 Running the program under Microsoft Windows

The main principle of running the program under Microsoft Windows is the same as running the programs under Linux. The user can easily start the program by just

double-click on ewrab-2.0.1 file only if the Cygwin is installed. The command promt window with standard outputs which are printed will appear. This window will be automatically closed regardless of whether the program has ended successfully or not. In other way, the user can start program from command line window (click on start icon, type cmd and enter, change directory where the program is located, type ewrab-2.0.1. This approach provides more control over how the program is running.

Chapter 7

Input files for EWR

Important remark: When editing the input files, keep attention *not to change quotation marks*. All files are read as sequential files and the program recognizes 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. Further, do not delete inputs you do not need for the given calculation. The program will automatically jump these inputs.

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 (INPUTR#.TXT, where '#' = 01, 02, 03 etc. and in the input file TEXTR_OUT.TXT using any text editor; the results files 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. 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 file TEXTR_OUT.TXT. You can translate all the text in this file. But be very careful not to change quotation marks.

7.1 Parameter files

The parameter *cb* which can take values 1 (only purebred progeny) or 2 (purebred and crossbred progeny) is determined by the codes for production system. Abbreviations given in the input files for each variable are those which are used in the program and in the list of variables in APPENDIX B in the Manual.

7.1.1 PARAR.TXT

- Production system for which economic values are calculated (*bsyst*)
- Genetic standard deviations for the breed of the doe in Production systems 1 or 2 are available and are to be read from INPUTR13.TXT (*std*)

  - 0: No
  - 1: Yes

- Genetic standard deviations for the traits of the sire breed its bucks are used for terminal crossing in Production systems 2 or 3 are available in INPUTR14.TXT and are to be read ($std2$)

  - 0: No
  - 1: Yes

- Genetic standard deviations for the traits of the dam breed in dam position producing crossbred replacement for the Production system 3 are available in INPUTR15.TXT and are to be read ($stdm1$)

  - 0: No
  - 1: Yes

- Genetic standard deviations for the traits of the dam breed in sire position producing crossbred replacement for the Production system 3 are available in INPUTR16.TXT and are to be read ($stdm2$)

  - 0: No
  - 1: Yes

7.1.2 Input file INPUTR01.TXT

- Maximum number of reproductive cycles a doe can reach (RR)
- Does died during reproductive cycles 1 to RR as proportion of does entering cycle 1 to RR. All values must be in the range from 0 to 1. It is assumed that does died from kindling to kits weaning ($pdfwD[i]$).
- Does culled in reproductive cycles 1 to RR-1 after kit weaning for health problems or bad mothering ability without being mated as proportion of does entering cycle 1 to RR. All values must be in the range from 0 to 1 ($pcwfD[i]$).
- Conception rate of does after mating (insemination) in reproductive cycles 1 to RR-1. Conception rate is defined as the number of does conceived as proportion of the number of does mated. The same conception rate is assumed for does entering a reproductive cycle with or without kindling ($conrateD[i]$).
- Number of does not pregnant after i-th kindling (i = 1,..RR-2), but kept to the next mating in the subsequent doe reproductive cycle, expressed as proportion of not pregnant does after i-th kindling. All values must be in the range from 0 to 1 ($pbarrD[i]$)
- Average weight of does just after kindling 1 to RR (averaged over does bearing purebred and crossbred litters if crossbreeding is applied) ($wfD[i]$)
- Average weight of does at 21th day of lactation in reproductive cycles 1 to RR. ($w21D[i]$)
- Average weight of does at weaning in reproductive cycles 1 to RR. The weight at weaning must not be higher than the weight at previous kindling.($wwD[i]$)

- Average (minimal) weight required for does which had kindling, but were culled after kit weaning for failure to conceive or other problems in reproductive cycles 1 to RR-1, and for age in cycle RR. ($wcD[i]$)
- Average weight of does which entered a cycle without kindling and were culled for health problems or for failure to conceive in reproductive cycles 2 to RR-1 (This weight must not be lower than the weight of does just after kindling in the appropriate cycle, $wcnpD[i]$)

/*The following vector variables are needed only in Production system 2 with partial terminal crossing*/

- Fraction of does crossed with other breeds in reproductive cycles 1 to RR-1. All values must be in the range from 0 to 1 ($pcrossD[i]$).

7.1.3 Input file INPUTR02.TXT

/* This file contains input parameters of reproduction and reproductive management in doe herds. The number of values in the vectors must be in accordance with the maximum number of reproductive cycles of does, i.g. with variable RR given in INPUTR01.TXT.

/*The following three inputs are read only in Production systems 1 and 2 for purebred litters.*/

- Total number of kits born in purebred litters per kindling in reproductive cycles $i = 1, \ldots, RR$ ($nb[i][0]$)
- Number of kits born alive in purebred litters per kindling in reproductive cycles $i = 1, \ldots, RR$ ($nba[i][0]$)
- Number of kits weaned in purebred litters per kindling in reproductive cycles $i = 1, \ldots, RR$ ($nw[i][0]$)

/*The following three inputs are read only in Production system 2 and 3 for the crossbred litters. */

- Total number of kits born in crossbred litters per kindling in reproductive cycles $i = 1, \ldots, RR$ ($nb[i][1]$)
- Number of kits born alive in crossbred litters per kindling in reproductive cycles $i = 1, \ldots, RR$ ($nba[i][1]$)
- Number of kits weaned in crossbred litters per kindling in reproductive cycles $i = 1, \ldots, RR$ ($nw[i][1]$)
- Interval between kindling and doe mating ($intkm$)
- Length of pregnancy ($lpreg$)
- Interval between mating and culling of does for failure to conceive ($inmcD$)

7.1.4 Input file INPUTR03.TXT

This file contains input parameters describing management and performance of young replacement does. In breeding system 1, values for crossbred young does are skipped.

- Female purebred kits alive at weaning as proportion of all purebred kits alive at that time ($pfP[0]$)

- Young replacement does died (mortality rate) during rearing (from weaning to 1st mating) expressed as proportion of female kits intended for rearing as breeding animals after weaning ($pdiedG$)
- Average age of purebred replacement does at first mating ($ageP[8][0]$)
- Average target weight of purebred replacement does at first mating ($wP[8][0]$)
- Average target weight of purebred replacement does at their second mating in the next mating cycle ($wP[9][0]$)
- Conception rate of young replacement does firstly mated. Conception rate is defined as the number of young does conceived as proportion of all firstly mated young does ($con1G$)
- Conception rate of young replacement does at second mating. This conception rate is defined as the number of the young does conceived after their second mating as proportion of all twice mated young does ($con2G$)
- Number of young does not pregnant after mating season, but kept to the next mating in the subsequent doe reproductive cycle, expressed as proportion of not pregnant young does after mating season. ($pbarrG$)
- Interval between mating and culling of young does for failure to conceived ($inmcG$). The same interval is assumed for non-pregnant young does culled after 1st and 2nd mating.
- Surplus purebred female kits intended for selling as young replacement expressed as proportion of all surplus purebred female kits at weaning ($pexG[0]$)

/* The following two inputs are read only if young replacement does are sold (exported, e.g. if the foregoing variable $pexG[0] > 0.0$) */

- Average age of purebred young breeding does sold (exported) outside the production system ($ageP[7][0]$)
- Average weight of purebred young breeding does sold (exported) outside the production system ($wP[7][0]$)

/*The following four parameters are read only in Production system 2 with partly terminal crossing.*/

- Fraction of young replacement does crossed with other breed ($pcrossD[0]$)
- Female crossbred kits intended for selling as young replacement expressed as proportion of crossbred female kits at weaning ($pexG[1]$)

/* The following two inputs are read only if young crossbred does are sold (exported, i.e. if the foregoing variable $pexG[1] > 0.0$) */

- Average age of crossbred young breeding does sold (exported) outside the production system ($ageP[7][1]$)
- Average weight of crossbred young breeding does sold (exported) outside the production system ($wP[7][1]$)

/*The following parameter is read only in Production systems 2 and 3*/

- Female crossbred kits alive at weaning as proportion of all crossbred kits alive at that time ($pfP[1]$)

/* The following four inputs are read for the purchased crossbred replacement does in Production system 3.*/

- Average age of crossbred replacement does at purchase ($agepF$)
- Average weight of crossbred replacement does at purchase (wpF)
- Average age of purchased crossbred replacement does at first mating ($ageP[8][0]$)
- Average target weight of purchased crossbred replacement does at first mating ($wP[8][0]$)
- Average target weight of purchased crossbred replacement does at their second mating in the next mating cycle ($wP[9][0]$)

7.1.5 Input file INPUTR04.TXT

This file contains parameters connected with mating management and breeding bucks. The data for bucks of a breed or cross different from the breed of the doe are skipped in Production system 1.

- Type of mating for bucks of the breed of the doe ($mtype[0]$)(1: AI is used for all matings; 2: natural mating is used throughout)

/* The following 4 inputs are read if the type of mating for bucks of the breed of the does is 1 */

- Young bucks of the breed of the does sold to AI stations that were culled on AI stations because of unsuitability for sperm collection as proportion of young bucks purchased ($pcullB[0]$)
- Number of sperm doses per young buck of the breed of the does (age 18 to 22 weeks) produced on AI station per time interval equal to the doe reproductive cycle (to the kindling interval) ($spermyB[0]$)
- Number of sperm doses per mature buck of the breed of the does (age $>$ 22 weeks) produced on AI station per time interval equal to the doe reproductive cycle (to the kindling interval) ($spermoB[0]$)
- Average productive lifetime of bucks of the breed of the does used for sperm collection on AI stations (from purchasing to AI to culling) ($lifespcyB[0]$)

/* The following 6 inputs are read if the type of mating for bucks of the breed of the does is 2 */

- Young bucks of the breed of the does intended for natural mating in the herds that were culled because of unsuitability for mating as proportion of young bucks reared for replacement ($pcullB[0]$)
- Does to young buck (18 to 22 weeks of age) ratio for bucks of the breed of the does when bucks are used for natural mating ($doeyB[0]$)
- Does to mature buck (older than 22 weeks) ratio for bucks of the breed of the does when bucks are used for natural mating ($doeoB[0]$)
- Average productive lifetime of bucks of the breed of the does used for natural mating ($lifenmB[0]$)
- Mature weight of adult bucks of the breed of the does ($wmB[0]$)

- Age of bucks of the breed of the does when reaching mature weight ($agemB[0]$)

/* Here start data for bucks of a breed or cross different from the breed of the does. This data are read only in Production systems 2 or 3. */

- Type of mating for bucks of a breed or cross different from the breed of the doe ($mtype[1]$) (1: AI is used for all matings; 2: natural mating is used throughout)

/* The following 6 inputs are read if the type of mating for bucks of a breed or cross different from the breed of the does is 2 */

- Young purchased bucks of a breed or cross different from the breed of the doe intended for natural mating which were culled because of unsuitability for mating as proportion of young bucks purchased for replacement ($pcullB[1]$)
- Does to young buck (18 to 22 weeks of age) ratio for bucks of a breed or cross different from the breed of the does when bucks are used for natural mating ($doeyB[1]$)
- Does to mature buck (older than 22 weeks) ratio for bucks of a breed or cross different from the breed of the does when bucks are used for natural mating ($doeoB[1]$)
- Average productive lifetime of bucks of a breed or cross different from the breed of the does used for natural mating ($lifenmB[1]$)
- Mature weight of adult bucks of a breed or cross different from the breed of the does ($wmB[1]$)
- Age of bucks of a breed or cross different from the breed of the does when reaching mature weight ($agemB[1]$)

7.1.6 Input file INPUTR05.TXT

This file contains parameters for male progeny reared as buck replacements and for purchased male replacements.

/* The following inputs are read for the progeny of the same genotype as the genotype of does (purebred progeny with index for genotype equal to 0) in Production systems 1 and 2. Inputs for non-existing categories in the given system are skipped.*/

- Young bucks of the breed of the does died (mortality rate) during rearing (from weaning to 1st using for mating or to selling to AI stations) expressed as proportion of male kits intended for rearing as buck replacement ($pdiedB[0]$)
- Male surplus purebred kits intended for selling as young replacement expressed as proportion of all surplus male purebred kits at weaning ($pexB[0]$)

/*The following two inputs are read if the variable $pexB[0] > 0.0$*/

- Average age of purebred breeding bucks sold (exported) ($ageP[16][0]$)
- Average weight of purebred breeding bucks sold (exported) ($wP[16][0]$)

/*The following two inputs are read if AI is applied, i.e. if the variable in INPUTR04.TXT $mtype[0] = 1$*/

- Weight of bucks at selling to AI stations ($wP[15][0]$)

- Age of bucks at selling to AI stations ($ageP[15][0]$)

/*The following four inputs are read if natural mating is applied, i.e. if the variable in INPUTR04.TXT $mtype[0] = 2$*/

- Average age at culling of purebred breeding bucks not suitable for mating ($ageP[13][0]$)
- Average weight at culling of purebred breeding bucks not suitable for mating ($wP[13][0]$)
- Weight of bucks at 1st used for mating ($wP[14][0]$)
- Age of bucks at 1st used for mating ($ageP[14][0]$)

/*The following two inputs are read for the purchased replacement bucks used for natural mating in crossbreeding in Production systems 2 and 3. They are read only if mating type in crossbreeding $mtype[1] = 2$*/

- Weight of bucks at 1st used for mating. It is assumed that this is the weight of bucks at purchase ($wP[14][1]$)
- Age of bucks at 1st used for mating. It is assumed that this is the age of bucks at purchase ($ageP[14][1]$)

7.1.7 Input file INPUTR06.TXT

This file contains parameters describing doe progeny until weaning and in fattening.

- Age of kits at weaning ($agew$)

/* The following 10 input parameters are read for the progeny of the same genotype as the genotype of does (purebred progeny in Production systems 1 and 2). */

- Average weight of a kit at birth ($bw[0]$)
- Average weight of a kit at 21 day of age ($w21[0]$)
- Average weight of weaned kits at weaning ($wP[3][0]$)

/*The following four values give the chemical composition of body composition of purebred newborn kits and these values must sum to 1.

If you have no specific estimates for your breed for the following parameters do not change these parameter, but use the default parameters as given in the example input files.*/

- Protein given as proportion of LW of born kits ($pmassb[0]$)
- Lipid (fat) given as proportion of LW of born kits ($lmassb[0]$)
- Water given as proportion of LW of born kits ($watb[0]$)
- Ash given as proportion of LW of born kits ($ashb[0]$)
- Mortality rate of kits in finishing (from weaning to slaughter) ($pdiedfP[0]$)
- Target slaughter weight of fattened kits ($wP[15[0]$)
- Average daily gain of kits in fattening ($adgP[5][0]$)

/* The following 10 inputs is read for the crossbred progeny, only in Production systems 2 and 3.*/

- Average weight of a kit at birth ($bw[1]$)
- Average weight of a kit at 21 day of age ($w21[1]$)
- Average weight of weaned kits at weaning ($wP[3][1]$)

/*The following four values give the chemical composition of body composition of crossbred newborn kits and these values must sum to 1. These values are read only in Production systems 2 and 3. **If you have no specific estimates for your breed for the following parameters do not change these parameter, but use the default parameters as given in the example input files.***/

- Protein given as proportion of LW of born kits ($pmassb[1]$)
- Lipid (fat) given as proportion of LW of born kits ($lmassb[1]$)
- Water given as proportion of LW of born kits ($watb[1]$)
- Ash given as proportion of LW of born kits ($ashb[1]$)
- Mortality rate of kits in finishing (from weaning to slaughter) ($pdiedfP[1]$)
- Target slaughter weight of fattened kits ($wP[15[1]$)
- Average daily gain of kits in fattening ($adgP[5][1]$)

7.1.8 Input file INPUTR07.TXT

This file contains the parameters used for the calculation of digestible energy requirement of growing rabbits (doe progeny = P). The abbreviation EBW in the units is used for empty body weight. For further details see Chapter 3. The default parameter values are mostly taken from [13]. **If you have no specific estimates for your breed for the following parameters do not change these parameter, but use the default parameters as given in the example input files.**

- Coefficient for the calculation of EBW or EBW gain from life weight (LW) or LW gain of growing rabbits ($ebwP$)
- Coefficient for the calculation of metabolic weight from LW of growing rabbits and does (bmP)
- Net energy retained in body protein (i.e. caloric value of body protein) ($pneP$)
- Net energy retained in body lipid (i.e. caloric value of body fat) ($lneP$)
- Digestible energy requirement for maintenance per day and per kg metabolic weight in thermoneutral environment (smP)
- Coefficient for the efficiency of utilisation of digestible energy (DE in feed) for protein gain in growing rabbits (kpP)
- Coefficient for the efficiency of utilisation of digestible energy (DE in feed) for lipid gain in growing rabbits (klP)

/*The following four values give the chemical composition of EBW gain of purebred growing rabbits and these values must sum to 1. These parameters are read also for replacement females in Production system 3. In this Production system, the values should be valid for the crossbred replacement with the doe genotype*/

- Protein given as proportion of EBW gain of growing animals ($pmassP[0]$)

- Lipid (fat) given as proportion of EBW gain of growing animals ($lmassP[0]$)
- Water given as proportion of EBW gain of growing animals ($watP[0]$)
- Ash given as proportion of EBG of growing animals ($ashP[0]$)

/*The following four values give the chemical composition of EBW gain of crossbred growing animals and these values must sum to 1. Read only in Production systems 2 and 3*/

- Protein given as proportion of EBW gain of growing animals ($pmassP[1]$)
- Lipid (fat) given as proportion of EBW gain of growing animals ($lmassP[1]$)
- Water given as proportion of EBW gain of growing animals ($watP[1]$)
- Ash given as proportion of EBG of growing animals ($ashP[1]$)

7.1.9 Input file INPUTR08.TXT

This file contains parameters used for the calculation of digestible energy requirement of reproductive does. For further details see Section 3. The default parameter values are mostly taken from Xiccato and Trocino 2010, in: Nutrition of the Rabbit, 2nd Edition (eds C. de Blas and J. Wiseman); CAB International 2010. **If you have no specific estimates for your breed for the following parameters do not change these parameter, but use the default parameters as given in the example input files.**

- Coefficient for the calculation of empty body weight (EBW) of does at kindling ($ebwD$)
- Net energy retained in body protein of does (i.e. caloric value of body protein) ($pneD$)
- Net energy retained in body lipid of does (i.e. caloric value of body fat) ($lneD$)
- Net energy retained in milk of does (i.e. caloric value of milk) ($milkneD$)
- Digestible energy requirement for maintenance of does per day and per kg metabolic weight in thermoneutral environment (smD)
- Net energy concentration in empty body of does at kindling ($neebwD$)
- Coefficient for the efficiency of utilisation of digestible energy (DE in feed) for protein gain in does (kpD)
- Coefficient for the efficiency of utilisation of digestible energy (DE in feed) for lipid gain in does (klD)
- Coefficient for the efficiency of utilisation of digestible energy (DE in feed) for milk production ($kmilkD$)
- Coefficient for the efficiency of utilisation of digestible energy (DE in feed) for foetus growth ($kpregD$)
- Coefficient for the efficiency of utilisation of body energy reserves for milk production in lactating non-pregnant does ($kmbrnpD$)
- Coefficient for the efficiency of utilisation of body energy reserves for milk production in lactating and pregnant does ($kmbrpD$)

/*The following four values give the chemical composition of EBW of pregnant does shortly before kindling, excluding pregnant uterus. These values must sum to 1*/

- Protein given as proportion of EBW (excluding pregnant uterus) of does at kindling ($pmassD$)
- Lipid (fat) given as proportion of EBW (excluding pregnant uterus) of does at kindling ($lmassD$)
- Water given as proportion of EBW (excluding pregnant uterus) of does at kindling ($watD$)
- Ash given as proportion of EBW (excluding pregnant uterus) of does at kindling ($ashD$)

/*The following four values give the chemical composition of EBW of not pregnant does shortly before theoretical kindling.
These values must sum to 1*/

- Protein given as proportion of EBW of does at theoretical kindling ($pmassnpD$)
- Lipid (fat) given as proportion of EBW of does at theoretical kindling ($lmassnpD$)
- Water given as proportion of EBW of does at theoretical kindling ($watnpD$)
- Ash given as proportion of EBW of does at theoretical kindling ($ashnpD$)

7.1.10 Input file INPUTR09.TXT

This file contains parameters needed for the calculation of feed requirement and nutrition costs.

- Average daily amount of water for a doe (lactating and non-lactating) ($waterD$)
- Average daily amount of water for growing rabbits after weaning ($waterP$)
- Price for water (prw)
- Amount of supplementary feed (prewening diet number 2) given purebred suckled kits until weaning ($tfP[2][3][0]$)
- Digestible energy content in fresh feed matter of supplementary feed (diet number 2) for kits until weaning ($defd[2]$)
- Price of fresh feed matter of supplementary feed (diet number 2) for kits until weaning ($prfd[2]$)
- Coefficient for feed wasting by kids until weaning (ratio of the feed amount given to the animal and of the feed amount really consumed) ($kfww$)
- Number of feeding phases (with different diets) for kits in fattening (from weaning to slaughter, nff). Insert 1 or 2.
- Age of kids when starting the second feeding phase in fattening (read only if $nff = 2$) ($agefw2$)
- Digestible energy content in fresh feed matter of diet number 3 in the first fattening phase ($defd[3]$)
- Price of fresh feed matter of diet number 3 in the first fattening phase ($prfd[3]$)

- Digestible energy content in fresh feed matter of diet number 4 in the second fattening phase; read only if $nff = 2$ ($defd[4]$)
- Price of fresh feed matter of diet number 4 in the second fattening phase; read only if $nff = 2$ ($prfd[4]$)
- Coefficient for feed wasting by rabbits in fattening (ratio of the feed amount given to the animal and of the feed amount relay consumed) ($kfwf$)
- Day of pregnancy when young pregnant does are starting to get a lactation diet ($dpregld$)
- Digestible energy content in fresh feed matter of lactation diet (number 1) ($defd[1]$)
- Price of fresh feed matter of lactation diet (number 1) ($prfd[1]$)
- Coefficient for feed wasting by does (ratio of the feed amount given to the animal and of the feed amount relay consumed) ($kfwd$)
- Digestible energy content in fresh feed matter of diet number 5 for rearing of young replacement does ($defd[5]$). If fattening diet is used for does replacement set the same value here as in fattening diet 3 or 4.
- Price of fresh feed matter of diet number 5 for rearing of young replacement does ($prfd[5]$). If fattening diet is used for does replacement set the same value here as in fattening diet 3 or 4.
- Coefficient for feed wasting in rearing of replacement (ratio of the feed amount given to the animal and of the feed amount relay consumed) ($kfwr$)
- Number of diet used for breeding bucks in rearing and natural mating. Insert the number of fattening diet 3 or 4 (nfb)
- Coefficient for feed wasting of bucks used for natural mating (ratio of the feed amount given to the animal and of the feed amount relay consumed)[1] ($kfwrB$)

/*The following parameter is read only in Production systems 2 and 3 for crossbred progeny*/

- Amount of supplementary feed (prewening diet number 2) given crossbred suckled kits until weaning ($tfP[2][3][1]$)

7.1.11 Input file INPUTR10.TXT

This file contains parameters needed for the calculation of non-feed costs. Parameters for non existing categories are skipped.

- Costs for artificial insemination including hormonal treatment of does if it is applied ($costAI$)
- Costs for health care of does including kits till weaning ($costhD$)
- Costs for health care of doe replacements from weaning to 1st mating ($costhrep1D$)

[1] This coefficient should be increased above the given ratio to take into account that bucks need some more feed to cover the energy requirement for semen production and for their sexual activity, which was not taken into account when calculating digestible energy requirements for bucks in Section 3.6

- Costs for health care of doe replacements from 1st to 2nd mating ($costhrep2D$)
- Costs for health care of buck replacements from weaning to selling to AI stations or to including in the herd for natural mating ($costhrepB$)
- Costs for health care of young breeding does intended for selling, in the interval from weaning to selling ($chsoldD$)
- Costs for health care of young breeding bucks intended for selling, in the interval from weaning to selling ($chsoldB$)
- Costs for health care of bucks used for natural mating in the herds ($costhB$)
- Costs for health care of animals in fattening (from weaning to slaughter, $costhfat$)
- Cost for supplies and miscellaneous of does including kits till weaning (i.e, bedding material $csupD$)
- Cost for supplies and miscellaneous of doe replacement in rearing ($csuprepD$)
- Cost for supplies and miscellaneous of buck replacement in rearing ($csuprepB$)
- Costs for supplies and miscellaneous of bucks used for natural mating in the herds ($csupB$)
- Costs for for supplies and miscellaneous of animals in fattening ($csupfat$)
- Fixed cost for does including kits till weaning (labour, depreciation costs for building and equipment, insurance, overhead costs etc., see Section 4.4.2, $fixD$)
- Fixed cost for doe replacement ($fixrepD$)
- Fixed cost for buck replacement ($fixrepB$)
- Fixed cost for bucks used in the herd for natural mating ($fixB$)
- Fixed cost for animals in fattening ($fixfat$)
- Marketing costs for fattened rabbits ($cmarkf$)
- Marketing costs for sold young breeding does ($cmarkG$)
- Marketing costs for sold young breeding bucks ($cmarkB$)
- Costs for disposal of dead animals ($cdead$)

/*The following input is read only in Production systems 2 and 3*/

- Price of bucks purchased for crossing ($prcrosB$)

/*The following input is read only in Production system 3*/

- Price of purchased doe replacement ($prrepD$)

7.1.12 Input file INPUTR11.TXT

This file contains parameters needed for the calculation of revenues. Chilled carcass contains heat, set of organs, liver, kidneys, perinatal and scapular fat. Reference carcass is defined as chilled carcass without heat, set of organs, liver and kidneys, i.e. it includes meat, bones and perinatal and scapular fat (see [6]).

- Pricing system for fattened rabbits and culled bucks. Insert the integer value 1 if price is given per kg live weight, 2 if price is given per kg carcass weight and 3 if price is given per kg fore, mid and hind part of carcasses. Setting pricing system 3 here, the program used automatically pricing system 2 for culled bucks. ($prfP$)

/*Input for Pricing System 1 fattened rabbits and culled bucks*/

- Price for slaughter rabbits ($prbfP$)

/*Inputs for Pricing System 2 fattened rabbits and culled bucks*/

- Average price for whole chilled carcass of slaughter rabbits ($prbfP$)

/*The following input is for purebred progeny. This input is not read in Production system 3*/

- Average dressing out percentage of chilled carcass of fattened rabbits (100 x weight of chilled carcass/slaughter weight, $dressR$[0])

/*The following input is for crossbred progeny. This input is not read in Production system 1*/

- Average dressing out percentage of chilled carcass of fattened rabbits (100 x weight of chilled carcass/slaughter weight, $dressR$[1])

/*Inputs for Pricing System 3 fattened rabbits*/

- Average price for fore part of the carcass ($prfore$)
- Average price for mid part of the carcass ($prmid$)
- Average price for hind part of the carcass ($prhind$)

/*The following five inputs are for purebred progeny. These inputs are not read in Production system 3*/

- Average dressing out percentage of chilled carcass of fattened rabbits (100 x weight of chilled carcass/slaughter weight, $dressR$[0])
- Weight of reference carcass given as percentage of chilled carcass (100 x weight of reference carcass/ weight of chilled carcass $prefc$[0])
- Average percentage of fore part in the reference carcass ($forep$[0])
- Average percentage of mid part in the reference carcass ($midp$[0])
- Average percentage of hind part in the reference carcass ($hindp$[0])

/*The following five inputs are for crossbred progeny. These inputs are not read in Production system 1*/

- Average dressing out percentage of chilled carcass of fattened rabbits (100 x weight of chilled carcass/slaughter weight, $dressR$[1])

- Weight of reference carcass given as percentage of chilled carcass ($prefc[1]$)
- Average percentage of fore part in the reference carcass ($forep[1]$)
- Average percentage of mid part in the reference carcass ($midp[1]$)
- Average percentage of hind part in the reference carcass ($hindp[1]$)
- Pricing system for culled does. Insert the integer value 1 if price is given per kg live weight, 2 if price is given per kg carcass weight or 3 if culled does can not be sold because of hormonal treatment ($prcD$)

/*Input for Pricing System 1 of does*/

- Price for culled does ($prbcD$)

/*Inputs for Pricing System 2 of does*/

- Average dressing out percentage of chilled carcass of does (100 x weight of chilled carcass/weight at culling,$dressD$)
- Price for carcasses of culled does ($prbcD$)
- Price for dried rabbit skin ($prskin$)
- Average weight of dried rabbit skin ($wskin$)
- Price for rabbit manure ($prmanure$)
- Amount of manure produced by does including kits till weaning ($wmanD$)
- Amount of manure produced by rabbits in fattening ($wmanfP$)
- Amount of manure produced by doe or buck replacement in rearing ($wmanrP$)
- Amount of manure produced by bucks used for natural mating ($wmanB$)

/*The following input is read in Production systems 1 and 2 if the mating type mtype[0]=1*/

- Price of young bucks sold to AI stations ($prAIB$)

/*The following input is read in Production systems 1 and 2 if $pexpG[0] > 0$ */

- Price of sold purebred young breeding does ($prG[0]$)

/*The following input is read in Production system 2 if $pexpG[1] > 0$ */

- Price of sold crossbred young breeding does ($prG[1]$)

/*The following input is read in Production systems 1 and 2 if $pexpB[0] > 0$*/

- Price of sold young breeding bucks (prB)

7.1.13 Input file INPUTR12.TXT

This file is necessary for the selection of the trait, for which the relative economic value should be calculated, from a group of alternative traits. The following selections are made:

- Select a litter size trait ($flag[1]$):
  - (3) Total number of kits born or
  - (4) Number of kits born alive or
  - (5) Number of kits weaned
- Select a trait for productive lifetime of does ($flag[2]$):
  - (9) Mortality rate of does or
  - (10) Average productive lifetime of does measured in number of reproductive cycles or
  - (11) Average productive lifetime of does measured in years
- Select between the following options for kit growth traits ($flag[3]$):
  - (13) Litter weight at weaning or
  - (14) Daily gain of kits between the 21th day of age till weaning
- Select a trait for feed efficiency in fattening ($flag[4]$):
  - (16) Residual feed intake in fattening or
  - (17) Feed conversion in fattening
- Select between the following options for carcass traits ($flag[5]$):
  - (19) Percentage of hind part in reference carcass
  - (20) Percentage of valuable parts (mid and hind parts) in reference carcass

7.1.14 Input file INPUTR13.TXT

This file is not need for Production system 3. The file contains the genetic standard deviations of all traits for doe breed in Production systems 1 or 2. It is read if these standard deviations are known which is controlled via the parameter *std* read in the parameter file PARAR.TXT. That parameter must be equal to 1 (see Subsection 7.1.1 on page 79). The genetic standard deviations are read only for those traits which are selected on the basis of INPUTR12.TXT. You need to insert the correct values only for traits selected in INPUTR12.TXT and for traits for which no alternative traits exists. **But do not delete default values for traits, you have not selected, because the program would not read the correct values. Keep attention that the genetic standard deviations are given in the correct units.** The file contains the following inputs (the number of trait according to Appendix A is given in parentheses):

- (1) Genetic standard deviation for conception rate of young does at first mating ($gsd\_d[1]$)
- (2) Genetic standard deviation for conception rate of does at first mating averaged over all parities ($gsd\_d[2]$)

- (3) Genetic standard deviation for total number of kits born ($gsd\_d[3]$)
- (4) Genetic standard deviation for number of kits born alive ($gsd\_d[4]$)
- (5) Genetic standard deviation for number of kits weaned ($gsd\_d[5]$)
- (6) Genetic standard deviation for percentage of stillborn kits averaged over all parities ($gsd\_d[6]$)
- (7) Genetic standard deviation for survival rate of kits born alive until weaning ($gsd\_d[7]$)
- (8) Genetic standard deviation for litter weight at 21th day of lactation ($gsd\_d[8]$)
- (9) Genetic standard deviation for doe mortality averaged over all parities ($gsd\_d[9]$)
- (10) Genetic standard deviation for average productive lifetime of does measured in number of reproductive cycles ($gsd\_d[10]$)
- (11) Genetic standard deviation for average productive lifetime of does measured in years ($gsd\_d[11]$)
- (12) Genetic standard deviation for survival rate of rabbits after weaning ($gsd\_d[12]$)
- (13) Genetic standard deviation for litter weight at weaning ($gsd\_d[13]$)
- (14) Genetic standard deviation for daily gain of kits from 21th day of age until weaning ($gsd\_d[14]$)
- (15) Genetic standard deviation for daily gain in fattening ($gsd\_d[15]$)
- (16) Genetic standard deviation for residual feed intake of rabbits during the whole fattening period ($gsd\_d[16]$)
- (17) Genetic standard deviation for feed conversion of rabbits during fattening ($gsd\_d[17]$)
- (18) Genetic standard deviation for dressing percentage of slaughtered rabbits after fattening ($gsd\_d[18]$)
- (19) Genetic standard deviation for percentage of hind part in the reference carcass of fattened rabbits ($gsd\_d[19]$)
- (20) Genetic standard deviation for percentage of valuable parts (mid and hind parts) in the reference carcass of fattened rabbits ($gsd\_d[20]$)

7.1.15 Input file INPUTR14.TXT

This file is not need for Production system 1. This file is necessary for program EWRAB. It contains genetic standard deviations of direct traits for sire breed used for terminal crossing in Production systems 2 or 3. It is used for the calculation of standardised and relative economic weights for bucks used for crossing. It is read if these standard deviations are known, i.e. if the parameter $std2 = 1$ in the parameter file PARAR.TXT. The file contains the genetic standard deviations only for the traits which are expressed in the terminal crossbred progeny and which were selected on the basis of INPUTR12.TXT. **You do not need to input values for the traits you did not select, but do not delete the default values. Keep**

attention that the genetic standard deviations are given in the correct units. The number of trait according to Appendix A in the Manual is given in parentheses.

- (12) Genetic standard deviation for the survival rate of rabbits in fattening ($gsd\_d2[12]$)
- (13) Genetic standard deviation for litter weight at weaning ($gsd\_d2[13]$)
- (14) Genetic standard deviation for daily gain of kits from 21th day of age until weaning ($gsd\_d2[14]$)
- (15) Genetic standard deviation for daily gain in fattening ($gsd\_d2[15]$)
- (16) Genetic standard deviation for residual feed intake of rabbits during the whole fattening period ($gsd\_d[16]$)
- (17) Genetic standard deviation for feed conversion of rabbits during fattening ($gsd\_d2[17]$)
- (18) Genetic standard deviation for dressing percentage of slaughtered rabbits after fattening ($gsd\_d2[18]$)
- (19) Genetic standard deviation for percentage of hind part in the reference carcass of fattened rabbits ($gsd\_d2[19]$)
- (20) Genetic standard deviation for percentage of valuable parts (mid and hind parts) in the reference carcass of fattened rabbits ($gsd\_d2[20]$)

7.1.16 Input file INPUTR15.TXT

This file is need only for Production system 3. This file is necessary for program EWRAB for the calculation of standardised and relative economic weights for dam breed which is used in dam position to produce crossbred doe replacement for Production system 3. The file contains the genetic standard deviations of all traits for this dam breed. It is read if these standard deviations are known, i.e. if the parameter $stdm1 = 1$ in the parameter file PARAR.TXT. The genetic standard deviations are read only for those traits which are selected on the basis of INPUTR12.TXT and for traits for which no alternative traits exist. **You do not need to input values for the traits you did not select, but do not delete the default values. Keep attention that the genetic standard deviations are given in the correct units.** The number of trait according to Appendix A in the Manual is given in parentheses.

- (1) Genetic standard deviation for conception rate of young does at first mating ($gsd\_dm1[1]$)
- (2) Genetic standard deviation for conception rate of does at first mating averaged over all parities ($gsd\_dm1[2]$)
- (3) Genetic standard deviation for total number of kits born ($gsd\_dm1[3]$)
- (4) Genetic standard deviation for number of kits born alive ($gsd\_dm1[4]$)
- (5) Genetic standard deviation for number of kits weaned ($gsd\_dm1[5]$)
- (6) Genetic standard deviation for percentage of stillborn kits averaged over all parities ($gsd\_dm1[6]$)

- (7) Genetic standard deviation for survival rate of kits born alive until weaning ($gsd\_dm1[7]$)
- (8) Genetic standard deviation for litter weight at 21th day of lactation ($gsd\_dm1[8]$)
- (9) Genetic standard deviation for doe mortality averaged over all parities ($gsd\_dm1[9]$)
- (10) Genetic standard deviation for average productive lifetime of does measured in number of reproductive cycles ($gsd\_dm1[10]$)
- (11) Genetic standard deviation for average productive lifetime of does measured in years ($gsd\_dm1[11]$)
- (12) Genetic standard deviation for survival rate of rabbits after weaning ($gsd\_dm1[12]$)
- (13) Genetic standard deviation for litter weight at weaning ($gsd\_dm1[13]$)
- (14) Genetic standard deviation for daily gain of kits from 21th day of age until weaning ($gsd\_dm1[14]$)
- (15) Genetic standard deviation for daily gain in fattening ($gsd\_dm1[15]$)
- (16) Genetic standard deviation for residual feed intake of rabbits during the whole fattening period ($gsd\_dm1[16]$)
- (17) Genetic standard deviation for feed conversion of rabbits during fattening ($gsd\_dm1[17]$)
- (18) Genetic standard deviation for dressing percentage of slaughtered rabbits after fattening ($gsd\_dm1[18]$)
- (19) Genetic standard deviation for percentage of hind part in the reference carcass of fattened rabbits ($gsd\_dm1[19]$)
- (20) Genetic standard deviation for percentage of valuable parts (mid and hind parts) in the reference carcass of fattened rabbits ($gsd\_dm1[20]$)

7.1.17 Input file INPUTR16.TXT

This file is need only for Production system 3. It is needed for the calculation of standardised and relative economic weights for dam breed used in sire position to produce crossbred doe replacements for Production system 3. The file contains the genetic standard deviations of all traits for this dam breed. It is read if these standard deviations are known, i.e. if the parameter $stdm2 = 1$ in the parameter file PARAR.TXT. The genetic standard deviations are read only for those traits which are selected on the basis of INPUTR12.TXT and for traits for which no alternative traits exist. **You do not need to input values for the traits you did not select, but do not delete the default values. Keep attention that the genetic standard deviations are given in the correct units**. The number of trait according to Appendix A in the Manual is given in parentheses.

- (1) Genetic standard deviation for conception rate of young does at first mating ($gsd\_dm2[1]$)
- (2) Genetic standard deviation for conception rate of does at first mating averaged over all parities ($gsd\_dm2[2]$)

- (3) Genetic standard deviation for total number of kits born ($gsd\_dm2[3]$)
- (4) Genetic standard deviation for number of kits born alive ($gsd\_dm2[4]$)
- (5) Genetic standard deviation for number of kits weaned ($gsd\_dm2[5]$)
- (6) Genetic standard deviation for percentage of stillborn kits averaged over all parities ($gsd\_dm2[6]$)
- (7) Genetic standard deviation for survival rate of kits born alive until weaning ($gsd\_dm2[7]$)
- (8) Genetic standard deviation for litter weight at 21th day of lactation ($gsd\_dm2[8]$)
- (9) Genetic standard deviation for doe mortality averaged over all parities ($gsd\_dm2[9]$)
- (10) Genetic standard deviation for average productive lifetime of does measured in number of reproductive cycles ($gsd\_dm2[10]$)
- (11) Genetic standard deviation for average productive lifetime of does measured in years ($gsd\_dm2[11]$)
- (12) Genetic standard deviation for survival rate of rabbits after weaning ($gsd\_dm2[12]$)
- (13) Genetic standard deviation for litter weight at weaning ($gsd\_dm2[13]$)
- (14) Genetic standard deviation for daily gain of kits from 21th day of age until weaning ($gsd\_dm2[14]$)
- (15) Genetic standard deviation for daily gain in fattening ($gsd\_dm2[15]$)
- (16) Genetic standard deviation for residual feed intake of rabbits during the whole fattening period ($gsd\_dm2[16]$)
- (17) Genetic standard deviation for feed conversion of rabbits during fattening ($gsd\_dm2[17]$)
- (18) Genetic standard deviation for dressing percentage of slaughtered rabbits after fattening ($gsd\_dm2[18]$)
- (19) Genetic standard deviation for percentage of hind part in the reference carcass of fattened rabbits ($gsd\_dm2[19]$)
- (20) Genetic standard deviation for percentage of valuable parts (mid and hind parts) in the reference carcass of fattened rabbits ($gsd\_dm2[20]$)

7.2 TEXTP_OUT.TXT

This file contains text which is used for printing the results. It contains 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 file read carefully the remarks at the beginning of Chapter 7.

Chapter 8

Output files from EWR

8.1 Results files

The name of the file the results are written to is automatically generated as *resR*.

If you want to carry out more calculations in the same directory, copy the results files first to a secure place before starting a new calculation, otherwise they will be overwritten by the new results.

The first part of the results file contains information on the version of the program, copyright and contact to the authors and the values of the system variables read PARAR.TXT (see Section 7.1.1). The second part of the file copies more or less the data input files INPUTR#.TXT where '#' is to be replaced by the corresponding numbers (01, 02, 03 etc.). The information read from the input files is selected according to the parameters given in the parameter file and in certain data input files. Therefore, the results file does not contain a simple copy of the input files, but only data from input files which will be needed for the given calculation.

The third part of the results file contains the results in the following order:

- Structure of the doe herd
- Survival and reproduction characteristics of the doe herd
- Characteristics of progeny
- Growth of animals in individual time periods
  - Growth of kits
  - Growth of breeding young does
  - Growth of breeding bucks in rearing
  - Growth of bucks used for natural mating
  - Growth of animals in finishing
  - Growth of does in the herd
- Feed and water costs
  - for progeny
  - for does
  - for bucks in the herd (used for natural mating)
- Non-feed and total costs

  - Non-feed costs
  - Total costs
  - Several cost items expressed in different ways
- Revenues
  - Revenues from culled does
  - Revenues from culled bucks
  - Revenues from progeny
    - Revenues from culled breeding animals
    - Revenues from fattened animals
    - Revenues from animals exported or sold to AI stations
  - Revenues from rabbit skins
  - Revenues from manure
  - Total revenues
  - Several revenue items expressed in different ways
- Total profit and profitability
- Marginal economic values
- Economic weights
  - Absolute economic weights
  - Standardised economic weights
  - Relative economic weights

8.2 Files listing the values of all variables at the end of the program

A further output of each program run is a file where the values of all variables and constants (except some index variables and temporary variables) of the program are listed mostly in alphabetic order. The name of the file is automatically generated and has the form CHECKR.

The file CHECKR deliver more complete information than the results files, but the information given in the results files should normally be sufficient for the user. However, the files CHECKR may be useful for a further development of the program. A special useful information from those files is that there are given two versions of calculated economic values: one version for a change of 0.5% down and upwards in the trait (variables $ev[i][j]$, which are printed in the results files) and a second one for a change of 1% to both sides in the trait (variables $ev0[i][j]$). The difference between these two numbers expressed in per cent ($evdiff[i][j]$) 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 or when there is a strong non-linear relationship between profit and the trait level.

8.3 File resRcsv.cs

popis prosim, k cemu to je

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Appendix A

Numbering of traits in program EWRAB

1. Conception rate of young does after the first mating (%)
2. Conception rate of does after the first mating averaged over all parities (%)
3. Total number of kits born (TNB)
4. Number of kits born alive (NBA)
5. Number of kits weaned (NW)
6. Percentage of stillborn kits (%)
7. Survival rate of kits born alive until weaning (%)
8. Litter weight at the 21th day of lactation (kg)
9. Doe mortality rate averaged over all parities (%)
10. Average productive lifetime of does measured in number of reproductive cycles
11. Average productive lifetime of does measured in years (years)
12. Survival rate of young rabbits in fattening (%)
13. Litter weight at weaning (kg)
14. Daily gain of kits between the 21th day of age and weaning (g/d)
15. Daily gain in fattening (g/d)
16. Residual daily feed intake during fattening (g/d)
17. Feed conversion during fattening (kg feed/kg gain)
18. Dressing percentage of fattened rabbits (%)
19. Percentage of hind part in the reference carcass of fattened rabbits (%)
20. Percentage of valuable parts (mid and hind parts) in the reference carcass of fattened rabbits (%)

Appendix B

Alphabetic list of variables in the program EWRAB

a	Used in the calculation of the stationary state of the doe herd
a1	Convergence criterion used in the calculation of the stationary state of the doe herd
aa1	Temporary variable
aa2	Temporary variable
aa3	Temporary variable
aa4	Temporary variable
aa5	Temporary variable
aa6	Temporary variable
adgB[j]	Daily gain (g/d) of bucks of genotype j ($j = 0, 1$) from their first used for mating to reaching mature weight
adgcD[i]	Average daily gain in body weight (g/d) for does from weaning after the i^{th} kindling ($i = 1, \ldots, RR - 1$) to culling for failure to conceive
adgP[i][j]	Average daily gain (g/d) of purebred ($j = 0$) or crossbred ($j = 1$) animals of progeny category i ($i = 1, \ldots, PP$)
adg21w[j]	Average daily gain of kits (g/d) genotype j ($j = 0, 1$) between the 21th day of age and weaning
ageavmat[0]	Average age (d) at mating (conceiving) of replacement does calculated as weighted average from the age at 1st and 2nd mating of replacement does
agefw2	Age of kids when starting the second feeding phase in fattening (only if $nff = 2$)
agemB[j]	Age (d) of bucks of genotype j ($j = 0, 1$) when reaching mature weight
ageP[i][j]	Age (d) of purebred ($j = 0$) or crossbred ($j = 1$) animals of progeny category i ($i = 1, \ldots, PP$) at the end of the time period for which that category is defined

agew	Age (d) of kits at weaning
arrDp	Average annual replacement rate of does (%)
ashb[j]	Ash given as proportion of LW of born kits of genotype j ($j = 0, 1$) (kg ash/kg LW)
ashD	Ash given as proportion of EBW (excluding pregnant uterus) of does at kindling (kg ash/kg EBW)
ashnpD	Ash given as proportion of EBW of non-pregnant does at kindling time of other pregnant does (kg ash/kg EBW)
ashP[j]	Ash given as proportion of EBW of growing rabbits of genotype j ($j = 0, 1$) (kg ash/kg EBW)
avlw[j]	Litter weight at weaning for litter genotype j ($j = 0, 1$)
bmP	Coefficient for the calculation of metabolic weight from LW of growing rabbits and does
bsyst	Production system (for details see input file 7.1.1)
bw[i]	Average birth weight (kg) of purebred ($i = 0$) or crossbred ($i = 1$) kits
bwlit[i]	Weight (kg) of the whole litter at birth in reproductive cycle i ($i = 1, \ldots, RR$) averaged over purebred and crossbred litters
C	Maximal number of categories of does + 1, set to 80
cb	Type of progeny (1: only purebred progeny, 2: purebred and crossbred progeny or only crossbred progeny)
cdead	Costs for disposal of dead animals (MU/kg)
chsoldB	Costs for health care of young breeding bucks intended for selling, in the interval from weaning to selling (MU/animal)
chsoldD	Costs for health care of young breeding does intended for selling, in the interval from weaning to selling (MU/animal)
cmarkf	Marketing costs for fattened rabbits (MU/animal)
cnfB[j]	Non-feed costs per buck of genotype j ($j = 0, 1$)
cnfD[i]	Non-feed costs per doe category$i$ ($i = 1, \ldots, TD$)
cnfP[i][j]	Non-feed costs per progeny category$i$ ($i = 1, \ldots, 16$) and genotype j ($j = 0, 1$)
con1G	Conception rate of young does after the 1st mating
con2G	Conception rate of young does after the 2nd mating
conrateD[i]	Conception rate of does in reproductive cycle i ($i = 1, \ldots, RR - 1$)
conrateD0	Conception rate of does averaged over all reproductive cycles
connyD	Number of young does pregnant (after the first and second mating) as proportion of young does firstly mated
costAI	Costs for artificial insemination including hormonal treatment of does if it is applied (MU/insemination)

costfB[i] Cost for feed (MU) including feed wasting from buck feed ration per buck of genotype i from including in the herd for natural mating to culling; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

costfP[i][j] Cost (MU) for feed per animal of progeny category i ($i = 1, \ldots, PP$) and genotype j ($j = 0, 1$) including feed wasting

costfD[i] Cost for feed (MU per animal) including feed wasting per doe of category i ($i = 1, \ldots, TD$)

costhB Costs for health care of bucks used for natural mating in the herds (MU/buck and kindling interval)

costhD Costs for health care of does including kits till weaning (MU/doe and kindling interval)

costhfat Costs for health care of animals in fattening (from weaning to slaughter) (MU/animal)

costhrepB Costs for health care of buck replacements from weaning to selling to AI stations or to including in the herd for natural mating (MU/animal)

costhrepD Costs for health care of doe replacements from weaning to 1st kindling (MU/animal)

csupB Costs for supplies and miscellaneous of bucks used for natural mating in the herds (MU/buck and day)

csupD Cost for supplies and miscellaneous of does including kits till weaning (i.e, bedding material) (MU/doe and day)

csupfat Costs for for supplies and miscellaneous of animals in fattening (MU/animal and day)

csuprepB Cost for supplies and miscellaneous of buck replacement in rearing (MU/buck and day)

csuprepD Cost for supplies and miscellaneous of doe replacement in rearing (MU/young doe and day)

d[i] The time for which a doe category i ($i = 1, \ldots, TD$) is defined

d1P[j] The length (d) of the first feeding period in fattening of purebred ($j = 0$) or crossbred ($j = 1$) progeny (only in the case that $nff = 2$)

d2P[j] The length (d) of the second feeding period in fattening of progeny of genotype j (only in the case that $nff = 2$)

dedayB[j] Total digestible energy requirement (kJ/day) for breeding bucks from their first used for mating to reaching mature weight

dedayP[i][j] Total digestible energy requirement (kJ DE/day) per animal of progeny category i ($i = 4, \ldots, PP$) and genotype j ($j = 0, 1$)

defetus[i][j] Total digestible energy needed for fetuses (MJ DE) during the whole pregnancy of does after kindling i ($i = 0, \ldots, RR$) for a doe bearing at kindling i purebred ($j = 0$) or crossbred ($j = 1$) litter (the value with the first index zero belongs to pregnant young doe replacements before first kindling)

defd[i] Digestible energy content in fresh feed matter (MJ DE/kg fresh matter of feed or kJ DE/g) of diet i ($i = 1, \ldots, FP$)

delipgB[j] Digestible energy requirements (kJ DE/day) for lipid gain per buck from 1st mating to reaching mature weight

delipgP[i][j] Digestible energy requirements (kJ DE/day) for lipid gain per animal of progeny category i ($i = 4, \ldots, PP$) and genotype j ($j = 0, 1$)

demB[j] Digestible energy requirements (kJ/day) for maintenance of breeding bucks of genotype j $j = 0, 1$) from 1st mating to reaching mature weight

demcB[j] Digestible energy requirements (kJ/day) for maintenance of breeding bucks of genotype j $j = 0, 1$) from reaching mature weight to culling

demP[i][j] Digestible energy requirements (kJ DE/day) for maintenance per animal of progeny category i ($i = 4, \ldots, PP$) and genotype j ($j = 0, 1$)

demnpcD[i] Digestible energy needed for maintenance (MJ DE) of non-pregnant does after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning and culling

dempD[i] Digestible energy needed for maintenance (MJ DE) of does after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning and the next kindling (without energy for maintenance of fetuses in pregnant does)

denkoD[i] Digestible energy requirement (MJ DE) for does entering cycle i $i = 2, \ldots, RR - 1$) without kindling in the period when these does are fed with feeding diet 6

denkpD[i] Digestible energy requirement (MJ DE) of a doe entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling in the period from the day of pregnancy when these does get lactation diet till kindling in cycle $i + 1$

deprotgP[i][j] Digestible energy requirements (kJ DE/day) for protein gain per animal of progeny category i ($i = 4, \ldots, PP$) and genotype j ($j = 0, 1$)

deprotgB[j] Digestible energy requirements (kJ DE/day) for protein gain per animal of bucks of genotype j ($j = 0, 1$) from the 1st mating to reaching mature weight

dmB[j] The length of period (d) from 1st use of breeding bucks (genotype j $j = 0, 1$) for mating to reaching mature weight

dmcB[j] The length of period (d) from reaching mature weight of bucks of genotype j $j = 0, 1$) to culling

doeoB[i] Doe (and young doe) to mature buck (older than 22 weeks) ratio when bucks are used for natural mating; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

doeyB[i] Doe (and young doe) to young buck (18 to 22 weeks of age) ratio when bucks are used for natural mating and eventually for oestrus stimulation; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

dP[i][j] The time (d) for which progeny category i ($i = 1, \ldots, PP$) of genotype j ($j = 0, 1$) is defined

dpregld Day of pregnancy when young pregnant does are starting to get a lactation diet

dressD Average dressing out percentage (%) of chilled carcass of does (100 x weight of chilled carcass/weight at culling)

dressR[j] Average dressing out percentage (%) of chilled carcass of fattened rabbits (100 x weight of chilled carcass/slaughter weight) of genotype j $j = 0, 1$)

ebgB[j] Empty body gain (g/d) of bucks of genotype j ($j = 0, 1$) from their first used for mating to reaching mature weight

ebgP[i][j] Empty body gain (g/day) of progeny category i ($i = 1, \ldots, PP$) and genotype j ($j = 0$: purebred animals, $j = 1$: crossbred animals)

ebwavmat11 Empty body weight (kg) of replacement does (category 11) at mating

ebwgnkpD[i] EBW gain (kg) of does entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling, being pregnant in this cycle and have kindling in cycle $i + 1$

ebwgnpcD[i] EBW gain (kg) for non-pregnant does after kindling i ($i = 1, \ldots, RR - 2$) in the period from kit weaning to culling

ebwgnp2D[i] EBW gain of does entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling and culled for health problems or failure to conceive

ebwgpD[i] Total empty (kg) body gain (kg) of does after kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning to the next kindling (without gain for fetuses in pregnant does)

ebwD Coefficient for the calculation of empty body weight (EBW) of does at kindling

ebwP Coefficient for the calculation of EBW or EBW gain from life weight (LW) or LW gain of growing rabbits

ebwpP11 Empty body weight (kg) of replacement does (category 11) just after 1st kindling

errmess Variable indicating the presence ($errmess = 1$) or the absence ($errmess = 0$) of an error during the calculation when running EWRAB

evp[i] Absolute economic weight of trait i for doe breed in Production systems 1 or 2

evmp[i] Absolute economic weight of trait i for both dam breeds producing crossbred doe replacement for Production system 3

evsp[i] Absolute economic weight of trait i for sires of breed used for terminal crossing in Production systems 2 or 3

ev[i][j] Marginal economic value of trait i expressed in purebred ($j = 0$) or crossbred ($j = 1$) animals calculated for changing the trait mean by $\pm 0.5\%$. For numbering of traits see Appendix A on page 102.

ev0[i][j] Marginal economic value of trait i expressed in purebred ($j = 0$) or crossbred ($j = 1$) animals calculated for changing the trait mean by $\pm 1\%$.

evdiff[i][j] Difference between the marginal economic weight calculated for changing the trait mean by $\pm 0.5\%$ and the marginal economic weight calculated for changing the trait mean by $\pm 1\%$, expressed in %:

$$evdiff[i][j] = 100 \times \frac{ev[i][j] - ev0[i][j]}{ev[i][j]}$$

evr[i] Relative economic weight (%) of trait i ($i = 1, \ldots, NT-1$) for doe breed in Production systems 1 or 2

evrm1[i] Relative economic weight (%) of trait i for dam breed used in dam position to produce crossbred doe replacement for Production system 3

evrm2[i] Relative economic weight (%) of trait i for dam breed used in sire position to produce crossbred doe replacement for Production system 3

evrs[i] Relative economic weight (%)t of trait i for sires of breed used for terminal crossing in Production systems 2 or 3

evst[i] Standardised economic weight for trait i ($i = 1, \ldots, NT - 1$)

F Number of decisions for selecting traits, set to 11

fB[i][j] Required feed fresh matter intake (g/d) of diets i ($i = 3$ or $i = 4$) for bucks of genotype j ($j = 0, 1$) from their first used for mating to reaching mature weight

fconv[j] Residual daily feed intake during fattening of rabbits of genotype j ($j = 0, 1$)

fintD The length (d) of doe reproductive cycles (i.e. the kindling interval)

fixB Fixed cost for bucks used in the herd for natural mating (MU/buck and day)

fixD Fixed cost for does including kits till weaning (labour, depreciation costs for building and equipment, insurance, overhead costs etc.) (MU/doe and day)

fixfat Fixed cost for animals in fattening (MU/animal and day)

fixrepB Fixed cost for buck replacement (MU/animal and day)

fixrepD Fixed cost for doe replacement (MU/animal and day)

flag[i] Chooses always between two or more trait definitions in the calculation of economic values. See Table B.1.

fmB[i][j] Requirement (g/day) intake of the fresh matter of the feeding diet i ($i = 3$ or $i = 4$) for breeding bucks from reaching mature weight to culling

tfnpc2D[k][i] Feed requirement (kg) of the fresh matter of the feeding diet k ($k = 6$) for a doe entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling, failed to conceive and being culled or of does culled for age after cycle RR, including feed wasting

Table B.1: Possible values of the variable $flag[i]$. The values of the variable correspond to the numbers of the trait as given in Appendix A.

Value of i	Possible values of $flag[i]$
1	3,4,5
2	9,10,11
3	13,14
4	16,17
5	19,20

tfnp2D[k][i] Feed requirement (kg) of the fresh matter of the feeding diet k ($k = 6$) for of does entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling and culled for health problems at time of kit weaning, including feed wasting

forep[j] Average percentage of fore part in the reference carcass (%) of fattened rabbits of genotype j ($j = 0, 1$)

FP Maximal number of different feed diets for rabbits, set to 6

fD[i][j] Total feed requirement of feeding ration j ($j = 1, 6$) for doe of category i ($i = 1, \ldots, TD$)

fP[k][i][j] Required daily feed intake (g\d) from diet k ($k = 1, \ldots, FP$) per progeny of category i ($i = 4, \ldots, PP$) and genotype j ($j = 0, 1$)

gsd_d[i] Genetic standard deviation for trait i ($i = 1, \ldots, NT - 1$) in doe breed in Production systems 1 or 2

gsd_d2[i] Genetic standard deviation for trait i ($i = 1, \ldots, NT - 1$) in sire breed used for crossing in Production systems 2 or 3

gsd_dm1[i] Genetic standard deviation for trait i ($i = 1, \ldots, NT - 1$) in dam breed used in dam position to produce crossbred doe replacement for Production system 3

gsd_dm2[i] Genetic standard deviation for trait i ($i = 1, \ldots, NT - 1$) in dam breed used in sire position to produce crossbred doe replacement for Production system 3

hindp[j] Average percentage of hind part in the reference carcass (in %) of fattened rabbits of genotype j ($j = 0, 1$)

i Index variable

i1 Index variable

i2 Index variable

i3 Index variable

imax Upper limit of index variable

imin Lower limit of index variable

incrossD The total number of crossbred matings (insemination) per doe per reproductive cycle including crossbred matings of young replacement does

inD The total number of matings (insemination) per doe per reproductive cycle including matings of young replacement does

inpurD	The total number of purebred matings (insemination) per doe per reproductive cycle including purebred matings of young replacement does
inmcD	Interval between mating and culling of does for failure to conceived.
inmcG	Interval between mating and culling of young does for failure to conceived. The same interval is assumed for non-pregnant young does culled after 1st and 2nd mating.
intkm	Interval (d) between kindling and mating
J	For differentiation of animals of the own or of a different breed or cross or for differentiation between purebred and crossbred progeny
j	Index variable
j1	Index variable
k	Index variable
k0	Index variable
k1	Index variable
kD	Number of iterations in the calculation of the stationary state of the structure of the doe herd
kfwd	Coefficient for feed wasting by does (kg feed used per animal/kg feed requirement per animal)
kfwf	Coefficient for feed wasting in finishing (kg feed used per animal/kg feed requirement per animal)
kfwr	Coefficient for feed wasting in rearing of replacement (kg feed used per animal/kg feed requirement per animal)
kfwrB	Coefficient for feed wasting of breeding bucks used for natural mating (kg feed used per animal/kg feed requirement per animal)
kfww	Coefficient for feed wasting by kits until weaning (kg feed used per animal/kg feed requirement per animal)
klD	Coefficient for the efficiency of utilisation of digestible energy (DE in feed) for lipid gain in does
klP	Coefficient for the efficiency of utilisation of digestible energy (DE in feed) for lipid gain in growing rabbits
kmbrnpD	Coefficient for the efficiency of utilisation of body energy reserves for milk production in lactating and non-pregnant does
kmbrpD	Coefficient for the efficiency of utilisation of body energy reserves for milk production in lactating and pregnant does
kmilkD	Coefficient for the efficiency of utilisation of digestible energy (DE in feed) for milk production
kpD	Coefficient for the efficiency of utilisation of digestible energy (DE in feed) for protein gain in does
kpP	Coefficient for the efficiency of utilisation of digestible energy (DE in feed) for protein gain in growing rabbits

kpregD Efficiency of utilisation of digestible energy from feed for fetus growth

l1_0[i] Needed for the calculation of $l1S[i]$ in the iteration process, $i = 1, \ldots, TD$

l1P[i][j] Number of animals of progeny category i ($i = 1, \ldots, PP$) and genotype j ($j = 0, 1$) per doe per reproductive cycle

l1D[i] Probability that in the stationary state of the whole production system a doe belongs to category i ($i = 1, ..., TS$)

l2D[i] Pregnant and non-pregnant does entering reproductive cycle i ($i = 1, ..., RR$) expressed as proportion of does entering any reproductive cycle ($\sum_{i=1}^{RR} l2D[i] = 1$)

l3D[i] Pregnant does entering reproductive cycle i ($i = 1, ..., RR$) expressed as proportion of does entering any reproductive cycle ($\sum_{i=1}^{RR} l2D[i] = 1$)

l4D[i] Non-pregnant does entering reproductive cycle i ($i = 1, ..., RR$) expressed as proportion of does entering any reproductive cycle ($\sum_{i=1}^{RR} l2D[i] = 1$)

lgain21[i] Lipid gain of growing does on parity i ($i = 1, \ldots, RR$) in the time period from kindling until the 21th day of lactation

lgainw[i] Lipid gain of does on parity i ($i = 1, \ldots, RR$) in the time period from the 22th day of lactation until kit weaning

lgnp2D[i] Total lipid gain (in kg) in EBW gain of does entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling and culled for health problems at time of kit weaning

lifenmB[i] Average productive lifetime (d) of bucks used for natural mating; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

lifenmcyB[i] Average productive lifetime of bucks used for natural mating expressed in number of doe reproductive cycles; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

lifespB[i] Average productive lifetime (d) of bucks used for sperm collection on AI stations where $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

lifespcyB[i] Average productive lifetime of bucks used for sperm production, expressed in number of doe reproductive cycles; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

lgnp2D[i] Total lipid gain (kg) in EBW gain of a doe entering reproductive cycle i ($i = 1, \ldots, RR-1$) without kindling and being culled for health problems or for failure to conceive

lgnkpD[i] Total lipid gain (kg) in EBW of a doe entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling, being pregnant in this cycle and have kindling in cycle $i + 1$

lipgnpcD[i] Total lipid gain (kg) in EBW of non-pregnant does after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning to culling

lipgpD[i] Total lipid gain (kg) in EBW of does after the kindling i ($i = 1, \ldots, RR-1$) in the period from kit weaning to the next kindling (without gain for fetuses in pregnant does)

lipgB[j] Average lipid gain (in g/day) of bucks of genotype j ($j = 0, 1$) from their first used for mating to reaching mature weight

lipgP[i][j] Average lipid gain (in g/day) of purebred ($j = 0$) or crossbred ($j = 1$) animals of progeny category i ($i = 1, \ldots, PP$)

ll1[i] Temporary variable of dimension R

ll2[i] Temporary variable of dimension R

lmassb[i] Lipid given as proportion of live weight of born purebred ($i = 0$) or crossbred ($i = 1$) kits (kg lipid/kg LW)

lmassP[j] Lipid (fat) given as proportion of EBW gain of growing purebred ($i = 0$) or crossbred ($i = 1$) rabbits (kg lipid/kg EBW)

lmassD Lipid given as proportion of EBW (excluding pregnant uterus) of does at kindling (kg lipid/kg EBW)

lmassnpD Lipid given as proportion of EBW of non-pregnant does at kindling time of other pregnant does (kg lipid/kg EBW)

lneP Net energy (MJ NE/kg lipid) retained in body lipid (i.e. caloric value of body fat) of growing rabbits

lneD Net energy (MJ NE/kg lipid) retained in body lipid (i.e. caloric value of body fat) of does

lpreg Length of pregnancy

lw21 Litter weight at 21 d of kits' age

midp[j] Average percentage of mid part in the reference carcass (%) of fattened rabbits of genotype j ($j = 0, 1$)

milk21[i][j] Milk yield (kg) of does on parity i ($i = 1, \ldots, RR$), bearing purebred ($j = 0$) or crossbred ($j = 1$) litter, in the period between kindling and the 21th day

milkneD Net energy (MJ NE/kg milk) retained in milk of does

milkw[i][j] Produced milk amount (in kg) in the time period from 22th day of lactation to kit weaning of a doe in parity i ($i = 1, \ldots, RR$) which was bearing purebred ($j = 0$) or crossbred ($j = 1$) litter

mkwnpcD[i] Average metabolic live weight (kg^{bmP}) of non-pregnant does after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning to culling

mkwpD[i] Average metabolic live weight (kg^{bmP}) of does after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning to the next kindling (without fetuses in pregnant does)

mlwP[i][j] Average metabolic live weight (kg^{bmP}) of progeny of category i ($i = 4, \ldots, PP$) and genotype j ($j = 0$: purebred progeny or $j = 1$: crossbred progeny)

mlwB[j] Average metabolic live weight (kg^{bmP}) of breeding bucks of genotype j ($j = 0, 1$) from their first used for mating to reaching mature weight

mnkpD[i] Average metabolic live weight (kg^{bmP}) of a doe entering reproductive cycle i ($i = 2, \ldots, RR-1$) without kindling, being pregnant in this cycle and have kindling in cycle $i + 1$

mnp2D[i] Average metabolic live weight (kg^{bmP}) of does entering reproductive cycle i ($i = 2, \ldots, RR-1$) without kindling and culled for health problems or failure to conceive

morbw[j] Mortality rate (in %) of kits of genotype $j = 0$ (purebred progeny) and $j = 1$ (crossbred progeny) averaged over doe reproductive cycles from birth till weaning

mtype[i] Type of mating (1: AI is used for all matings; 2: natural mating is used throughout) where $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

mlw21[i] Average metabolic weight (kg^{bmP}) of does on parity i ($i = 1, \ldots, RR$) in the period from kindling to the 21th day of lactation

mwfetus[i][j] Average metabolic weight of fetuses (kg^{bmP}) in pregnant does after kindling i ($i = 0, \ldots, RR$) for a doe bearing at kindling $i + 1$ purebred ($j = 0$) or crossbred ($j = 1$) litter (the value with the first index zero belongs to pregnant young doe replacements before first kindling)

mlww[i] Average metabolic weight (kg^{bmP}) of does on parity i ($i = 1, \ldots, RR$) in the period from the 22th day of lactation until kit weaning

n2 Number of the data input file

nAID[j] Number of sperm doses from bucks of genotype j (where $j = 0$ refers to bucks of the same breed as the breed of the does and $j = 1$ is used if the buck is of a different breed or cross) needed per doe and per reproductive cycle including sperm doses for young replacement does

nb[i][j] Total number of kits born per kindling in reproductive cycle i where $i = 1, \ldots, RR$; $j = 0$ refers to purebred litters and $j = 1$ refers to crossbred litters

nbt[j] Total number of kits born per doe entering any cycle (with and without kindling) in the herd averaged over reproductive cycles; $j = 0$ refers to purebred litters and $j = 1$ refers to crossbred litters

nb0[i] Total number of kits born per kindling in reproductive cycle i ($i = 1, \ldots, RR$) averaged over purebred and crossbred litters

nba[i][j] Number of kits born alive per kindling in reproductive cycle i where $i = 1, \ldots, RR$; $j = 0$ refers to purebred litters and $j = 1$ refers to crossbred litters

nbat[j] Number of kits born alive per doe entering any cycle (with and without kindling) in the herd averaged over reproductive cycles; $j = 0$ refers to purebred litters and $j = 1$ refers to crossbred litters

nba0[i] Number of kits born alive per kindling in reproductive cycle i ($i = 1, \ldots, RR$) averaged over purebred and crossbred litters

ncyD Number of doe reproductive cycle per year

nebr21[i] Net energy (MJ NE) available for milk production from body reserves of non-pregnant does on parity i ($i = 1, \ldots, RR$)

nebrwp[i] Net energy (MJ NE) available for milk production from body reserves of pregnant does on parity i ($i = 1, \ldots, RR$)

nebrwnp[i] Net energy (MJ NE) available for milk production from body reserves of non-pregnant does on parity i ($i = 1, \ldots, RR$)

neebwD Net energy concentration (MJ NE/kg EBW) in empty body of does at kindling

nefetus[i][j] Total net energy needed for fetuses (MJ NE) during the whole pregnancy of does after kindling i ($i = 0, \ldots, RR$) for a doe bearing at kindling $i + 1$ purebred ($j = 0$) or crossbred ($j = 1$) litter (the value with the first index zero belongs to pregnant young doe replacements before first kindling)

nelipnpcD[i] Net energy retained (MJ NE) in lipid of the empty body weight gain of non-pregnant does after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning and culling

nelippD[i] Net energy retained (MJ NE) in lipid of the empty body weight gain of does after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning and the next kindling

nelit21w[i][j] Total net energy requirement (kJ NE) for the whole purebred ($j = 0$) or crossbred ($j = 1$) litter of does on parity i ($i = 1, \ldots, RR$) in the period from the 22th day of age until weaning

demfetus[i][j] Digestible energy needed for maintenance (MJ DE) of fetuses during the whole pregnancy of does after kindling i ($i = 0, \ldots, RR$) for a doe bearing at kindling $i + 1$ purebred ($j = 0$) or crossbred ($j = 1$) litter (the value with the first index zero belongs to pregnant young doe replacements before first kindling)

nemilk21[i][j] Net energy retained in milk (MJ NE) in the period between kindling and the 21th day of lactation of a doe on parity i ($i = 1, \ldots, RR$) that was bearing purebred ($j = 0$) or crossbred ($j = 1$) litter

nemilk21w[i][j] Net energy (MJ NE) for the whole purebred ($j = 0$) or crossbred ($j = 1$) litter of a doe on parity i ($i = 1, \ldots, RR$) in the period between the 22th day of age and weaning that must be covered from milk

neprotnpcD[i] Net energy retained (MJ NE) in protein of the empty body weight gain of pregnant does after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning and culling

neprotpD[i] Net energy retained (MJ NE) in protein of the empty body weight gain of does after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning and the next kindling

nfb Number of diet used for breeding bucks in rearing and natural mating. Insert the number of fattening diet 3 or 4.

nff Number of feeding phases (with different diets) for kits in fattening (values 1 or 2).

nfP[i] Number of female purebred ($i = 0$) or crossbred ($i = 1$) kits alive at weaning

nkind The number of kindlings in the doe herd per doe and per reproductive cycle

nmatB[i] Number of matings including does and young does per doe and reproductive cycle where $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

nmat1G Number of firstly mated young does per doe and per reproductive cycle

nmat2G Number of young does mated for the second time per doe and per reproductive cycle

nmP[i] Number of male purebred ($i = 0$) or crossbred ($i = 1$) kits alive at weaning

npD Number of does entered a reproductive cycle without kindling per doe in the herd

nsfP[i] Number of surplus purebred ($i = 0$) or crossbred ($i = 1$) female kits at weaning per doe and per reproductive cycle

nsmP[i] Number of surplus purebred ($i = 0$) or crossbred ($i = 1$) male kits at weaning per doe and per reproductive cycle

nstg1D Number of states for does in the last reproductive cycle, set to 2 (see Subsection 2.2 on page 12)

nstgD Number of states for does in all but the last reproductive cycles, set to 5 (see Subsection 2.2 on page 12)

NT Maximal number of traits + 1, set to 36

numnmB[i] Number of bucks (both young and mature bucks) needed for natural mating per doe per reproductive cycle; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

numnmyB[i] Number of young bucks necessary for natural mating, per doe of the breed the bucks are used for and per reproductive cycle; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

numspB[i] Overall number of bucks (both young and mature bucks) needed for sperm production per doe of the breed for which the sperm is used and per reproductive cycle where $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

numspyB[i] Number of young bucks that must be reared and sold to AI stations or used for sperm production on farms, per doe of the breed the buck sperm is used for and per reproductive cycle; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

numyB[i] Total number of young bucks that must be reared until the age when bucks are used for first mating (for sperm production or natural mating) per doe of the breed the bucks are used for and per reproductive cycle; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

nurreplB[i] Number of bucks of genotype i that must be reared after weaning as replacement of bucks used for sperm production or for natural mating per doe and per reproductive cycle; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

nurreplG The number of young does that must be reared after weaning for own herd replacement (not including young does exported as breeding animals outside the breeding system) per doe per reproductive cycle

nw[i][j] Number of kits weaned per kindling in reproductive cycle i where $i = 1, \ldots, RR$; $j = 0$ refers to purebred litters and $j = 1$ refers to crossbred litters

nw0[i] Number of kits weaned per kindling in reproductive cycle i ($i = 1, \ldots, RR$) averaged over purebred and crossbred litters

nwt[j] Number of kits weaned per doe entering any cycle (with and without kindling) in the herd averaged over reproductive cycles; $j = 0$ refers to purebred litters and $j = 1$ refers to crossbred litters

P Maximal number of categories of progeny + 1, set to 17

p4[i] Does entering cycle i without kindling expressed as a fraction of does entering cycle i

p5[i] Does entering cycle i with kindling expressed as a fraction of does entering cycle i

pbarrD[i] Number of does not pregnant after kindling i ($i = 1, \ldots, RR - 1$), but kept to the next mating in the subsequent doe reproductive cycle, expressed as proportion of not pregnant does after kindling i

pbarrG Number of young does not pregnant after mating season, but kept to the next mating in the subsequent doe reproductive cycle, expressed as proportion of not pregnant young does after mating season

pcageD0 Culling rate for age

pcageDp Does culled for age in the last reproductive cycle as percentage of does replaced

pconD[i] Does pregnant in reproductive cycle i ($i = 1, \ldots, RR - 1$) expressed as a fraction of does entering cycle i

pconstayD[i] Does entering the next reproductive cycle $i + 1$ ($i = 1, \ldots, RR - 2$) with and without kindling expressed as fraction of does entered cycle i

pcrossD[i] Does crossed with other breeds in reproductive cycle i as proportion of does mated in cycle i ($i = 0, \ldots, RR - 1$). The value for $i = 0$ means young does crossed (reproductive cycle=0). All values must be in the range from 0 to 1.

pcrosst — Females (young and mature does) mated with bucks of a different breed as proportion of all mated females (i.e. fraction of crossing in the herd)

pcullB[j] — Bucks of genotype intended for natural mating or sperm production that were culled for unsuitability for mating or sperm production, where $j = 0$ refers to bucks of the same breed as the breed of the does and $j = 1$ is used if the buck is of a different breed or cross

pcullD[i] — Does culled in reproductive cycle i ($i = 1, \ldots, RR - 1$) for failure to conceive expressed as fraction of does entering cycle i

pcullD0 — Culling rate for failure to conceive averaged over all reproductive cycles

pcullDp — Does involuntary culled for failure to conceive as percentage of does replaced

pcwfD[i] — Does culled in reproductive cycle i ($i = 1, \ldots, RR$) shortly after kit weaning for health problems, bad mothering ability or for age (in the last reproductive cycle) without being mated as proportion of does entering cycle i

pcwfD0 — Culling rate for health problems or bad mothering ability after weaning averaged over all reproductive cycles

pcwfDp — Does involuntary culled for health problems or bad mothering ability as percentage of does replaced

pdfwD[i] — Does died in reproductive cycle i ($i = 1, \ldots, RR$) from kindling to kit weaning as proportion of does entering reproductive cycle i. All values must be in the range from 0 to 1.

pdfwD0[i] — Original values of $pdfwD[i]$ (needed for the calculation of economic values)

pdiedB[i] — Bucks died (mortality rate) during rearing (from weaning to used for mating or to selling) expressed as proportion of male kits intended for rearing as breeding animals after weaning; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

pdiedG — Young does died (mortality rate) during rearing expressed as proportion of female kits intended for rearing as breeding animals after weaning. The same mortality rate is assumed for purebred and crossbred young does.

pdiedfP[i] — Animal died during finishing expressed as proportion of animals entered finishing; $i = 0$ refers to purebred animals and $i = 1$ is used for crossbred animals

pdiedD0 — Mortality rate of does averaged over all reproductive cycles

pdiedDp — Does died as percentage of does replaced

pexB[i] — Male kits intended for selling (export) as breeding bucks after rearing expressed as proportion of surplus male kits at weaning; $i = 0$ refers to purebred animals and $i = 1$ is used for crossbred animals

pexG[i] — Female kits intended for selling (export) as breeding young does after rearing expressed as proportion of surplus female kits at weaning; $i = 0$ refers to purebred animals and $i = 1$ is used for crossbred animals

pfP[i] Female kits alive at weaning as proportion of all kits (of both sexes) alive at that time; $i = 0$ refers to purebred animals and $i = 1$ is used for crossbred animals

pgain21[i] Protein gain of growing does on parity i ($i = 1, \ldots, RR$) in the time period from kindling until the 21th day of lactation

pgainw[i] Protein gain of does on parity i ($i = 1, \ldots, RR$) in the time period from the 22th day of lactation until kit weaning

pgnkpD[i] Total protein gain (kg) in EBW of a doe entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling, being pregnant in this cycle and have kindling in cycle $i + 1$

pgnp2D[i] Total protein gain (in kg) in EBW gain of does entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling and culled for health problems or failure to conceived

pltD[i] Productive lifetime (d) of does of category i, i.e. the time from the first kindling to culling or death

pltdD Productive lifetime (d) of does, averaged over all categories of does

pltnfD Productive lifetime of does averaged over all categories of does and expressed in number of kindlings

pltyD Productive lifetime (yr) of does, averaged over all categories of does

pmassb[i] Protein given as proportion of live weight of born purebred ($i = 0$) or crossbred ($i = 1$) kits (kg protein/kg LW)

pmassD Protein given as proportion of EBW (excluding pregnant uterus) of does at kindling (kg protein/kg EBW)

pmassnpD Protein given as proportion of EBW of non-pregnant does at kindling time of other pregnant does (kg protein/kg EBW)

pmassP[j] Protein given as proportion of EBW gain of growing purebred ($i = 0$) or crossbred ($i = 1$) rabbits (kg protein/kg EBW)

pmatD[i] Does mated in reproductive cycle i ($i = 1, \ldots, RR - 1$) expressed as fraction of does entered cycle i

pneD Net energy (MJ NE/kg protein) retained in body protein (i.e. caloric value of body protein) of does

pneP Net energy (MJ NE/kg protein) retained in body protein (i.e. caloric value of body protein) of growing rabbits

pnmyB[i] Number of young bucks as proportion of all bucks of the same genotype used for natural mating; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

PP Number of progeny categories

ppurt Females (young and mature does) mated with bucks of the same breed as proportion of all mated females

prAIB Price of young bucks sold to AI stations (MU/animal)

prB	Price of sold young breeding bucks (MU/animal)
prbcD	Price for culled does (MU/kg live or carcass weight)
prcD	Pricing system for culled does. The following integer values should be inserted: 1 if price is given per kg live weight, 2 if price is given per kg carcass weight or 3 if culled does can not be sold because of hormonal treatment and had to be removed.
prcrosB	Price of bucks purchased for crossing (MU/animal)
prG	Price of sold young breeding does (MU/animal)
prrepD	Price of purchased doe replacement (MU/animal)
prbfP	Price of slaughter rabbits (MU/kg live or carcass weight)
prefc[i]	Weight of reference carcass expressed as percentage of chilled carcass of rabbits genotype i ($i = 0, 1$)
prfd[i]	Price per kg fresh feed matter of diet i ($i = 1, \ldots, FP$) (MU/kg))
prfP	Pricing system for fattened rabbits and culled bucks. The variable takes values 1 (price for live weight), 2 (price for carcass weight) or 3 (price according to valuable parts of carcasses).
prfore	Average price per kg of fore part of the rabbit carcass (MU/kg)
prhind	Average price per kg of hind part of the rabbit carcass(MU/kg)
prmanure	Price for rabbit manure (MU/100 kg)
prmid	Average price per kg of mid part of the rabbit carcass (MU/kg)
prof	Profitability (%) of the rabbit production system
protgP[i][j]	Average protein gain (in g/day) of purebred ($j = 0$) or crossbred ($j = 1$) animals of progeny category i ($i = 1, \ldots, PP$)
protgnpcD[i]	Total protein gain (kg) in EBW of non-pregnant does after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning to culling
protgpD[i]	Total protein gain (kg) in EBW of does after the kindling i ($i = 1, \ldots, RR-1$) in the period from kit weaning to the next kindling (without gain for fetuses in pregnant does)
protgB[j]	Average protein gain (in g/day) of bucks of genotype j ($j = 0, 1$) from their first used for mating to reaching mature weight
prskin	Price for dried rabbit skin
prmanure	Price for rabbit manure
prw	Price (MU/m^3) for water
pspyB[i]	Number of young bucks used for sperm production as proportion of all bucks of the same genotype used for sperm production; $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

pstayD[i] Does not pregnant in reproductive cycle i ($i = 1, \ldots, RR-1$), but kept to the next reproductive cycle expressed as fraction of does entered cycle i

pstill[j] Percentage of stillborn kits of genotype $j = 0$ (purebred progeny) and $j = 1$ (crossbred progeny) averaged over doe reproductive cycles

pstill0 Percentage of stillborn kits averaged over doe reproductive cycles and over genotype of the litters

R Maximal number of reproductive cycles for does + 1, set to 16

revBcy Revenues (MU) for culled bucks (used in the herd for natural mating) per doe in the herd (including does without kindling) per reproductive cycle

revcB[j] Revenues (MU) per culled buck of genotype j ($j = 0, 1$) that was used in the herd for natural mating

revcD[i] Revenues (MU) per culled doe of category i

revfPcy Revenues (MU) for fattened progeny per doe in the herd (including does without kindling) per reproductive cycle

revP[i][j] Revenues (MU) per animal of progeny category i ($i = 1, \ldots, PP$) and genotype j ($j = 0, 1$)

revPcy Revenues from all progeny categories per doe in the herd (including does without kindling) per reproductive cycle

revDcy Revenues (MU) for culled does per doe in the herd (including does without kindling) per reproductive cycle

rfiP[k][i][j] Residual feed intake (kg) required from progeny feed ration k ($k = 2, \ldots, FP$) per animal of category i ($i = 4, \ldots, PP$) and genotype j ($j = 0, 1$)

rmanBcy Revenues from manure of bucks used for natural mating per doe per reproductive cycle

rmanDcy Revenues from manure of does per doe per reproductive cycle

rmanfPcy Revenues from manure of fattened progeny per doe per reproductive cycle

rmanrPcy Revenues from manure of reared replacement does and bucks per doe per reproductive cycle

RR Number of reproductive cycles for does in the given Production system; it must take values between 6 and 15

rskinBcy Revenues for skin of culled bucks (used in the herd for natural mating) per doe in the herd (including does without kindling) per reproductive cycle

rskinDcy Revenues for skin of culled does per doe in the herd (including does without kindling) per reproductive cycle

rskinPcy Revenues for skin of culled and slaughtered progeny per doe in the herd (including does without kindling) per reproductive cycle

sevst — Sum of the absolute values of the standardised economic weights over all selected traits (see INPUTR12.TXT - Subsection 7.1.13) for doe breed in Production systems 1 or 2

sevstm1 — Sum of the absolute values of the standardised economic weights over all selected traits for dam breed used in dam position to produce crossbred doe replacement for Production system 3

sevstm2 — Sum of the absolute values of the standardised economic weights over all selected traits for dam breed used in sire position to produce crossbred doe replacement for Production system 3

sevsts — Sum of the absolute values of the standardised economic weights over all selected traits for sires of breed used for terminal crossing in Production systems 2 or 3

sl1D — Sum of the elements of vector $l1D[i]$ ($sl1D = \sum_{i=1}^{TD} l1D[i]$); this sum must be 1 if the calculation is correct

smP — Standard digestible energy (MJ DE per kg metabolic body weight and per day) requirement for maintenance of growing rabbits (also bucks) housed in thermoneutral environment

smD — Standard digestible energy (MJ DE per kg metabolic body weight and per day) requirement for maintenance of does (pregnant and open) housed in thermoneutral environment

spermoB[i] — Number of sperm doses per mature buck (age $>$ 22 weeks) produced per time interval equal to the doe kindling interval, where $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

spermyB[i] — Number of sperm doses per young buck (age 18 to 22 weeks) produced per a time interval equal to the doe kindling interval, where $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

srB[i] — Survival rate (%) of bucks of genotype i in rearing where $i = 0$ refers to bucks of the same breed as the breed of the does and $i = 1$ is used if the buck is of a different breed or cross

srfP[j] — Survival rate (%) of animals of genotype j ($j = 0$: purebred animals, $j = 1$: crossbred animals) in fattening

srG — Survival rate of young does during rearing (%)

std — Indicator variable if the genetic standard deviations of traits for the breed of does in Production systems 1 or 2 (INPUTR13.TXT) are to be read (0: No, 1: Yes)

std2 — Indicator variable if the genetic standard deviations of traits for the breed of sires used for terminal crossing in Production systems 2 or 3 (INPUTR14.TXT) are to be read (0: No, 1: Yes)

stdm1 — Indicator variable if the genetic standard deviations of traits for the dam breed used in dam position to produce crossbred doe replacement for Production system 3 (INPUTR15.TXT) are to be read (0: No, 1: Yes)

stdm2 Indicator variable if the genetic standard deviations of traits for the dam breed used in sire position to produce crossbred doe replacement for Production system 3 (INPUTR16.TXT) are to be read (0: No, 1: Yes)

surbw[j] Survival rate (in %) of kits of genotype j ($j = 0$: purebred litters, $j = 1$: crossbred litters) from birth till weaning averaged over all reproductive cycles

surbw0 Survival rate (%) of kits born alive until weaning averaged over genotypes of kits and over reproductive cycles

tckgfP Total costs (MU) per kg slaughter weight of fattened rabbits

tcostDcy Total costs (MU) per doe in the herd per reproductive cycle (including does entering a cycle without kindling)

tcostDy Total costs (MU) per doe in the herd per year (including does entering a cycle without kindling)

tcostfP The total costs (MU) per fattened rabbit

tde21[i][j] Total digestible energy (MJ DE) requirement of does on parity i ($i = 1, \ldots, RR$), bearing purebred ($j = 0$) or crossbred ($j = 1$) litter, in the period between kindling and the 21th day of lactation

tdeP11 Total digestible energy (in MJ DE) needed for maintenance and growth of replacement does (of category 11) in the whole period from mating to 1st kindling

tdegP11 Total digestible energy needed for growth of empty body weight (in MJ DE) of replacement does (of category 11) from mating to 1st kindling

tdenpc2D[i] Total digestible energy (MJ DE) requirement of a doe entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling, failed to conceive and being culled or of does culled for age after cycle RR

tdenpcD[i] Total digestible energy (MJ DE) requirement for non-pregnant does after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning and culling

tdenp2D[i] Total digestible energy (MJ DE) requirement of does entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling and culled for health problems at time of kit weaning

tdepD[i][j] Total digestible energy requirement (MJ DE) for pregnant does after the kindling i ($i = 1, \ldots, RR - 1$), bearing at the next kindling purebred ($j = 0$) or crossbred ($j = 1$) litter , in the period from kit weaning and the next kindling

tdemP11 Total digestible energy needed for maintenance (in MJ DE) of replacement does (category 11) from mating to 1st kindling

tdewnp[i][j] Total digestible energy requirement (MJ DE) from feed for a non-pregnant does on parity i ($i = 1, \ldots, RR$), bearing purebred ($j = 0$) or crossbred ($j = 1$) litter, in the period from the 22th day of lactation until kit weaning

tdewp[i][j] Total digestible energy requirement (MJ DE) from feed for a pregnant does on parity i ($i = 1, \ldots, RR$), bearing purebred ($j = 0$) or crossbred ($j = 1$) litter, in the period from the 22th day of lactation until kit weaning

tf21D[k][i][j] Amount (kg) of fresh matter of the feeding diet k ($k = 1$) for a doe on parity$i$ ($i = 1, \ldots, RR$), bearing purebred ($j = 0$) or crossbred ($j = 1$) litter, in the period between kindling and the 21th day of lactation including feed wasting

tfB[i][j] Total amount of fresh feed matter (kg) from feeding diet i ($i = 3$ or $i = 4$) per breeding buck of genotype j ($j = 0, 1$) from his first used for mating to culling taken into account feed wasting

tfDcy Total feeding costs per doe in the herd per reproductive cycle (include feeding costs for doe and progeny categories and for bucks used for natural mating)

tfP[k][i][j] Total amount (kg) of fresh feed matter from diet k ($k = 1, \ldots, FP$) per animal progeny category i ($i = 4, \ldots, PP$) and genotype j ($j = 0, 1$) including feed wasting

tfP[2][3][j] Amount of supplementary feed given suckled kits until weaning (kg fresh feed matter/kit)

tfnkoD[6][i] Amount (kg) of the fresh matter of the feeding diet k ($k = 1$) for a doe entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling in the period until the day *dpregld* of pregnancy when she obtained diet number 6 including feed wasting

tfnkpD[k][i][j] Amount (kg) of the fresh matter of the feeding diet k ($k = 1$) for a doe entering reproductive cycle i ($i = 2, \ldots, RR - 1$) without kindling in the period from the day *dpregld* of pregnancy till kindling where the doe bear litter of genotype j ($j = 0, 1$) including feed wasting

tfwknpcD[k][i] Amount (kg) of the fresh matter of the feeding diet k ($k = 6$) for a non-pregnant doe after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning and culling including feed wasting

tfwknpD[k][i] Amount (kg) of the fresh matter of the feeding diet k ($k = 6$) for a non-pregnant doe after the kindling i ($i = 1, \ldots, RR - 1$) in the period from kit weaning and the next kindling time including feed wasting

tfwkpD[k][i][j] Amount (kg) of the fresh matter of the feeding diet k ($k = 1$) for a pregnant doe after the kindling i ($i = 1, \ldots, RR - 1$), bearing at the next kindling purebred ($j = 0$) or crossbred ($j = 1$) litter, in the period from kit weaning and the next kindling including feed wasting

tfwnpD[k][i][j] Amount (kg) of the fresh matter of the feeding diet k ($k = 1$) for a non-pregnant does on parity i ($i = 1, \ldots, RR$), bearing purebred ($j = 0$) or crossbred ($j = 1$) litter, in the period from the 22th day of lactation until kit weaning including feed wasting

tfwpD[k][i][j] Amount (kg) of the fresh matter of the feeding diet k ($k = 1$) for a pregnant does on parity i ($i = 1, \ldots, RR$), bearing purebred ($j = 0$) or crossbred ($j = 1$) litter, in the period from the 22th day of lactation until kit weaning including feed wasting

tnef[2][i][j] Total net energy (MJ NE) available from diet k ($k = 2$) for the whole purebred ($j = 0$) or crossbred ($j = 1$) litter of a doe on parity$i$ ($i = 1, \ldots, RR$) in the period between the 22th day of age and weaning

to[i] Indicator for traits taking values 0 or 1 ($i = 1, \ldots, NT - 1$).

0	Economic values are not printed for these traits.
1	Economic values are printed for these traits.

tlgP11 Total lipid gain (kg) of replacement does (category 11) from mating (conceiving) to 1st kindling

tnfDcy Total non-feed costs in MU per doe in the herd per reproductive cycle (include non-feed costs for doe and progeny categories and for bucks used for natural mating)

tpgP11 Total protein gain (kg) of replacement does (category 11) from mating (conceiving) to 1st kindling

Tprof Total profit (MU per doe per year, including does without kindling)

Tprofcy Total profit (MU per doe per reproductive cycle, including does without kindling)

Tprofh In the calculation of economic weights: Value of $Tprof$ for the increased value of the trait

Tprofl In the calculation of economic weights: Value of $Tprof$ for the decreased value of the trait

Tprofm In the calculation of economic weights: Value of $Tprof$ for the average value of the trait

Tproff Total profit (MU per finished rabbit)

TprofkgfP Total profit (MU per kg slaughter weight of finished rabbits)

trait Number of the trait

trevDcy Total revenues (MU) per doe in the herd (including does without kindling) per reproductive cycle

trevDy Total revenues (MU) per doe in the herd (including does without kindling) per year

trevfP Total revenues (MU) per finished rabbit

trkgfP Total revenues (MU) per kg slaughter weight of finished rabbits

TD Dimension of the transmission matrix for the doe herds in the given calculation (= Number of doe categories)

td[i][j] Elements of the transmission matrix for the calculation of the structure of the doe herd ($i, j = 1, ..., TS$)

tv2h In the calculation of economic weights: increased value of a 2nd trait

tv2l In the calculation of economic weights: decreased value of a 2nd trait

tv2m In the calculation of economic weights: average value of 2nd trait

tv3h In the calculation of economic weights: increased value of a 3rd trait

tv3l In the calculation of economic weights: decreased value of a 3rd trait

tv3m In the calculation of economic weights: average value of a 3rd trait

tvh In the calculation of economic weights: increased value of the trait

tvl In the calculation of economic weights: decreased value of the trait

tvm In the calculation of economic weights: average value of the trait

twgfetus[i][j] Total weight gain of fetuses (kg) during the whole pregnancy of does after kindling i ($i = 0, \ldots, RR$) for a doe bearing at the next kindling $i + 1$ purebred ($j = 0$) or crossbred ($j = 1$) litter (the value with the first index zero belongs to pregnant young doe replacements before first kindling)

valp[j] Percentage of valuable parts (mid and hind parts) in reference carcass of fattened rabbits of genotype j, ($j = 0$ for purebred, $j = 1$ for crossbred animals)

w21D[i] Average weight of does at 21th day of lactation in reproductive cycles i ($i = 1, \ldots, RR$)

w21[j] Average weight of a purebred ($j = 0$) or crossbred ($j = 1$) kit at 21 days of age

watD Water given as proportion of EBW (excluding pregnant uterus) of does at kindling

watP[i] Water given as proportion of EBW gain of growing animals of genotype j, ($j = 0$ for purebred, $j = 1$ for crossbred animals)

waterD Daily amount of water (l per d and animal) per doe (lactating and non-lactating)

waterP Daily amount of water (l per d and animal) for growing rabbits after weaning

wavmat[0] Average weight (kg) at mating (conceiving) of replacement does calculated as weighted average from the weight at 1st and 2nd mating of replacement does

wcD[i] Average weight of does culled after kit weaning for failure to conceive or other problems in reproductive cycles i ($i = 1, \ldots, RR - 1$) and for age in cycle $i = RR$

wcnpD[i] Average weight of does entering a cycle i ($i = 1, \ldots, RR - 1$) without kindling and culled for failure to conceive or other problems*/

wfD[i] Average weight of does just after kindling 1 to RR (In Production system 2 averaged over does bearing purebred and crossbred litters)

wlfetus[i][j] Total lipid gain (kg) during doe pregnancy after kindling i ($i = 0, \ldots, RR$) for does bearing in the next kindling $i+1$ purebred ($j = 0$) or crossbred ($j = 1$) litter (value with the first index zero are fetuses of replacement does before first kindling)

wloss21[i] Loss of weight (kg) of a doe during the first 21 days of lactation in parity i (i 1,. . . ,RR), averaged over purebred and crossbred litters

wlossw[i] Loss of weight (kg) of does on parity i (i 1,...,RR) from the 22th day of lactation to kit weaning averaged over purebred and crossbred litters

wmanB Amount of manure (kg) produced by bucks used for natural mating per animal per day

wmanD Amount of manure (kg) produced by does including kits till weaning per doe per day

wmanfP Amount of manure (kg) produced by rabbits in fattening per animal per day

wmanrP Amount of manure (kg) produced by replacement doe or buck per day

wmB[j] Weight of adult bucks of genotype j, $(j = 0, 1)$

wP[i][j] Weight (kg) of purebred $(j = 0)$ or crossbred $(j = 1)$ animals of progeny category i at the end of the time period for which that category is defined

wskin Average weight of dried rabbit skin

wpfetus[i][j] Total protein gain (kg) of fetuses during doe pregnancy after kindling i $(i = 0, \ldots, RR)$ for does bearing in the next kindling $i + 1$ purebred $(j = 0)$ or crossbred $(j = 1)$ litter (value with the first index zero are fetuses of replacement does before first kindling

wwlit[i] Weight (kg) of the whole litter at weaning in reproductive cycle i $(i = 1, \ldots, RR)$ averaged over purebred and crossbred litters

wwD[i] Average weight of does at weaning in reproductive cycles i $(i = 1, \ldots, RR)$. The weight at weaning must not be higher than the weight at previous kindling.

z1 Variable used for numbering the headlines in the results file

z2 Variable used for numbering the headlines in the results file

z3 Variable used for numbering the headlines in the results file

zr Number of the loop of the program

zz Running number for printing the outline in the results file

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