

## Multiple trait animal model

### Model description

Example is from Mrode: Linear Models for the Prediction of Animal Breeding Values (CAB International, 1996, p. 80-84).

The multiple trait animal model has the form:

$$\mathbf{y} = \mathbf{X}\mathbf{b} + \mathbf{Z}\mathbf{a} + \mathbf{e},$$

where

$\mathbf{y}$  is vector of observations for pre-weaning and post-weaning gain,

$\mathbf{b}$  is vector of fixed sex effects,

$\mathbf{X}$  is design matrix to link observations to appropriate fixed effects,

$\mathbf{a}$  is vector of random additive genetic animal effects,

$\mathbf{Z}$  is design matrix to link observations to appropriate random effects, and

$\mathbf{e}$  is random residual vector.

It is assumed that  $\text{var}(\mathbf{a}) = \mathbf{A} \otimes \mathbf{G}_0 = \mathbf{G}$ ,  $\text{var}(\mathbf{e}) = \mathbf{I} \otimes \mathbf{R}_0 = \mathbf{R}$  and  $\text{cov}(\mathbf{a}, \mathbf{e}) = \text{cov}(\mathbf{e}, \mathbf{a}) = \mathbf{0}$ , where  $\mathbf{G}_0$  and  $\mathbf{R}_0$  are  $2 \times 2$ -matrices of variance and covariance components for random animal effects and residuals, respectively, and  $\mathbf{A}$  is the numerator relationship matrix.

Variance-covariance matrices are

$$\mathbf{G}_0 = \begin{bmatrix} 20.0 & 18.0 \\ 18.0 & 40.0 \end{bmatrix}$$

and

$$\mathbf{R}_0 = \begin{bmatrix} 40.0 & 11.0 \\ 11.0 & 30.0 \end{bmatrix}$$

### Input files

#### Datafile:

The data file contains information on the data to be analyzed together with class and regression variables for the model. The data file can be in free format (columns are separated by at least one space) or in binary format.

Each record, i.e., line in a free format file, has been divided to two parts: 1) Integer number columns and 2) real number columns. Columns of real numbers are always after the integer number columns.

MT.dat

4	1	4.5	6.8
5	2	2.9	5.0
6	2	3.9	6.8
7	1	3.5	6.0
8	1	5.0	7.5

Column 1: Animal ID (integer)

Column 2: Sex (integer)

Column 3: Pre-weaning gain (real)  
Column 4: Post-weaning gain (real)

### **Pedigree file:**

All the pedigree information must be given in the pedigree file. Each animal in the pedigree must have a record with four integers of which the fourth integer is optional.

MT.ped

1	0	0	
2	0	0	
3	0	0	
4	1	0	
5	3	2	
6	1	2	
7	4	5	
8	3	6	

Column 1: Animal ID  
Column 2: Sire ID  
Column 3: Dam ID

### **Variance component file:**

The variance components file has variances and covariances for all the random effects in the model. The variance component file has a line for each (co)variance. Order of lines in the file is irrelevant.

MT.var

1	1	1	20.0
1	1	2	18.0
1	2	2	40.0
2	1	1	40.0
2	1	2	11.0
2	2	2	30.0

Column 1: Random effect number (integer)  
Column 2: Row index (integer)  
Column 3: Column index (integer)  
Column 4: (Co)variance value (real)

### **Command file:**

CLIM instructions for a multiple trait animal model. Everything beyond '#' sign is considered as a comment.

MT.clm

```

TITLE      Multiple-trait model; (R. Mrode, example 5.1)

DATAFILE   MT.dat           # Data file
INTEGER    animal sex       # Integer column names
REAL       preWWGT postWWGT # Real column names

DATASORT   PEDIGREECODE=animal

PEDFILE    MT.ped           # Pedigree file
PEDIGREE   animal am        # Genetics associated with animal code:
                                # am=animal model

PARFILE    MT.var           # Variance component file

PRECON     b f              # Preconditioner: b=block diagonal, f=full block

MODEL
  preWWGT  = sex animal     # 1st trait
  postWWGT = sex animal     # 2nd trait

```

## Solution files

Structure of the formatted solution files depends on the model. Therefore, explanation of the content of those files is given in the printout of the particular run of the program.

MiX99-solver program has been run by command `mix99s -s`, meaning that in all parts of the program default values are used.

"Solfix"-file contains solutions for fixed effects.

Fact.	Trt	Level	N-Obs	Solution	Factor	Trait
1	1	1	3	4.3609	SEX	PREWWGT
1	2	1	3	6.7999	SEX	POSTWWGT
1	1	2	2	3.3973	SEX	PREWWGT
1	2	2	2	5.8803	SEX	POSTWWGT

Column 1: Factor number

Column 2: Trait number

Column 3: Level code

Column 4: Number of observations

Column 5: Solution

Column 6: Name of factor

Column 7: Name of trait

"Solani"-file contains solutions for genetic animal effect.

1	2	0	0.15092	0.27960
2	2	0	-.15393E-01	-.76101E-02
3	2	0	-.78392E-01	-.17034
4	1	1	-.10239E-01	-.12671E-01
5	1	1	-.27033	-.47783
6	1	1	0.27581	0.51724
7	0	1	-.31612	-.47898
8	0	1	0.24376	0.39196

Column 1: Animal ID

Column 2: Number of descendants

Column 3: Number of observations

Column 4: Solution for trait 1 preWWGT and factor animal

Column 5: Solution for trait 2 postWWGT and factor animal