

# Package ‘hsrecombi’

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**Type** Package

**Title** Estimation of Recombination Rate and Maternal LD in Half-Sibs

**Version** 1.1.1

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**Description** Paternal recombination rate and maternal linkage disequilibrium (LD) are estimated for pairs of biallelic markers such as single nucleotide polymorphisms (SNPs) from progeny genotypes and sire haplotypes. The implementation relies on paternal half-sib families. If maternal half-sib families are used, the roles of sire/dam are swapped. Multiple families can be considered. For parameter estimation, at least one sire has to be double heterozygous at the investigated pairs of SNPs.

Based on recombination rates, genetic distances between markers can be estimated. Markers with unusually large recombination rate to markers in close proximity (i.e. putatively misplaced markers) shall be discarded in this derivation.

\*A pipeline is available at GitHub\*

<<https://github.com/wittenburg/hsrecombi>>

Hampel, Teuscher, Gomez-Raya, Doschoris, Wittenburg (2018) ``Estimation of recombination rate and maternal linkage disequilibrium in half-sibs''

<[doi:10.3389/fgene.2018.00186](https://doi.org/10.3389/fgene.2018.00186)>.

Gomez-Raya (2012) ``Maximum likelihood estimation of linkage disequilibrium in half-sib families'' <[doi:10.1534/genetics.111.137521](https://doi.org/10.1534/genetics.111.137521)>.

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---

bestmapfun	<i>Best fitting genetic-map function</i>
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---

## Description

Approximation of mixing parameter of system of map functions

## Usage

```
bestmapfun(theta, dist_M)
```

**Arguments**

theta            vector of recombination rates  
dist\_M          vector of genetic positions

**Details**

The genetic mapping function that fits best to the genetic data (recombination rate and genetic distances) is obtained from Rao's system of genetic-map functions. The corresponding mixing parameter is estimated via 1-dimensional constrained optimisation. See vignette for its application to estimated data.

**Value**

list (LEN 2)

**mixing** mixing parameter of system of genetic mapping functions

**mse** minimum value of target function  $(\text{theta} - \text{dist\_M})^2$

**References**

Rao, D.C., Morton, N.E., Lindsten, J., Hulten, M. & Yee, S (1977) A mapping function for man. Human Heredity 27: 99-104. doi:10.1159/000152856

**Examples**

```
theta <- seq(0, 0.5, 0.01)
gendist <- -log(1 - 2 * theta) / 2
bestmapfun(theta, gendist)
```

---

checkCandidates            *Candidates for misplacement*

---

**Description**

Search for SNPs with unusually large estimates of recombination rate

**Usage**

```
checkCandidates(final, map1, win = 30, quant = 0.99)
```

**Arguments**

final	table of results produced by editraw with pairwise estimates of recombination rate between p SNPs within chromosome; minimum required data frame with columns SNP1, SNP2 and theta
map1	data.frame containing information on physical map, at least: SNP SNP ID which must coincide with SNP name in genotype.chr locus_Mb physical position in Mbp of SNP on chromosomes Chr chromosome of SNP
win	optional value for window size; default value 30
quant	optional value; default value 0.99, see details

**Details**

Markers with unusually large estimates of recombination rate to close SNPs are candidates for misplacement in the underlying assembly. The mean of recombination rate estimates with win subsequent or preceding markers is calculated and those SNPs with mean value exceeding the quant quantile are denoted as candidates which have to be manually curated! This can be done, for instance, by visual inspection of a correlation plot containing estimates of recombination rate in a selected region.

**Value**

vector of SNP IDs for further verification

**References**

Hampel, A., Teuscher, F., Gomez-Raya, L., Doschoris, M. & Wittenburg, D. (2018) Estimation of recombination rate and maternal linkage disequilibrium in half-sibs. *Frontiers in Genetics* 9:186. [doi:10.3389/fgene.2018.00186](https://doi.org/10.3389/fgene.2018.00186)

**Examples**

```
### test data
data(targetregion)
### make list for paternal half-sib families
hap <- makehaplist(daughterSire, hapSire)
### parameter estimates on a chromosome
res <- hsrecombi(hap, genotype.chr)
### post-processing to achieve final and valid set of estimates
final <- editraw(res, map.chr)
### check for candidates of misplacement
snp <- checkCandidates(final, map.chr)
```

---

countNumbers	<i>Count genotype combinations at 2 SNPs</i>
--------------	--

---

**Description**

Count genotype combinations at 2 SNPs

**Arguments**

X                    integer matrix of genotypes

**Value**

count vector of counts of 9 possible genotypes at SNP pair

---

daughterSire	<i>targetregion: allocation of paternal half-sib families</i>
--------------	---

---

**Description**

Vector of sire ID for each progeny

**Usage**

daughterSire

**Format**

An object of class integer of length 265.

---

editraw	<i>Editing results of hsrecombi</i>
---------	-------------------------------------

---

**Description**

Process raw results from hsrecombi, decide which out of two sets of estimates is more likely and prepare list of final results

**Usage**

editraw(Roh, map1)

**Arguments**

Roh list of raw results from hsrecombi  
 map1 data.frame containing information on physical map, at least:  
       SNP SNP ID which must coincide with SNP name in genotype.chr  
       locus\_Mb physical position in Mbp of SNP on chromosomes  
       Chr chromosome of SNP

**Value**

final table of results  
 SNP1 index 1. SNP  
 SNP2 index 2. SNP  
 D maternal LD  
 fAA frequency of maternal haplotype 1-1  
 fAB frequency of maternal haplotype 1-0  
 fBA frequency of maternal haplotype 0-1  
 fBB frequency of maternal haplotype 0-0  
 p1 Maternal allele frequency (allele 1) at SNP1  
 p2 Maternal allele frequency (allele 1) at SNP2  
 nfam1 size of genomic family 1  
 nfam2 size of genomic family 2  
 error 0 if computations were without error; 1 if EM algorithm did not converge  
 iteration number of EM iterations  
 theta paternal recombination rate  
 r2  $r^2$  of maternal LD  
 logL value of log likelihood function  
 unimodal 1 if likelihood is unimodal; 0 if likelihood is bimodal  
 critical 0 if parameter estimates were unique; 1 if parameter estimates were obtained via decision process  
 locus\_Mb physical distance between SNPs in Mbp

**Examples**

```
### test data
data(targetregion)
### make list for paternal half-sib families
hap <- makehaplist(daughterSire, hapSire)
### parameter estimates on a chromosome
res <- hsrecombi(hap, genotype.chr)
### post-processing to achieve final and valid set of estimates
final <- editraw(res, map.chr)
```

---

felsenstein	<i>Felsenstein's genetic map function</i>
-------------	---

---

**Description**

Calculation of genetic distances from recombination rates given an interference parameter

**Usage**

```
felsenstein(K, x, inverse = F)
```

**Arguments**

K	parameter (numeric) corresponding to the intensity of crossover interference
x	vector of recombination rates
inverse	logical, if FALSE recombination rate is mapped to Morgan unit, if TRUE Morgan unit is mapped to recombination rate (default is FALSE)

**Value**

vector of genetic positions in Morgan units

**References**

Felsenstein, J. (1979) A mathematically tractable family of genetic mapping functions with different amounts of interference. *Genetics* 91:769-775.

**Examples**

```
felsenstein(0.1, seq(0, 0.5, 0.01))
```

---

geneticPosition	<i>Estimation of genetic position</i>
-----------------	---------------------------------------

---

**Description**

Estimation of genetic positions (in centi Morgan)

**Usage**

```
geneticPosition(final, map1, exclude = NULL, threshold = 0.05)
```

**Arguments**

<code>final</code>	table of results produced by <code>editraw</code> with pairwise estimates of recombination rate between <code>p</code> SNPs within chromosome; minimum required data frame with columns <code>SNP1</code> , <code>SNP2</code> and <code>theta</code>
<code>map1</code>	data.frame containing information on physical map, at least: <code>SNP</code> SNP ID which must coincide with SNP name in <code>genotype.chr</code> <code>locus_Mb</code> physical position in Mbp of SNP on chromosomes <code>Chr</code> chromosome of SNP
<code>exclude</code>	optional vector ( <code>LEN &lt; p</code> ) of SNP IDs to be excluded (e.g., candidates of misplaced SNPs; default <code>NULL</code> )
<code>threshold</code>	optional value; recombination rates $\leq$ <code>threshold</code> are considered for smoothing approach assuming $\theta \sim \text{Morgan}$ (default 0.05)

**Details**

Smoothing of recombination rates ( $\theta$ )  $\leq 0.05$  via quadratic optimization provides an approximation of genetic distances (in Morgan) between SNPs. The cumulative sum \* 100 yields the genetic positions in cM.

The minimization problem  $(\theta - D d)^2$  is solved s.t.  $d > 0$  where  $d$  is the vector of genetic distances between adjacent markers but  $\theta$  is not restricted to adjacent markers. The incidence matrix  $D$  contains 1's for those intervals contributing to the total distance relevant for each  $\theta$ .

Estimates of  $\theta = 1e-6$  are neglected as these values coincide with start values and indicate that (because of a very flat likelihood surface) no meaningful estimate of recombination rate has been obtained.

**Value**

list (LEN 2)

**gen.cM** vector (LEN `p`) of genetic positions of SNPs (in cM)

**gen.Mb** vector (LEN `p`) of physical positions of SNPs (in Mbp)

**References**

Qanbari, S. & Wittenburg, D. (2020) Male recombination map of the autosomal genome in German Holstein. *Genetics Selection Evolution* 52:73. doi:10.1186/s1271102000593z

**Examples**

```
### test data
data(targetregion)
### make list for paternal half-sib families
hap <- makehaplist(daughterSire, hapSire)
### parameter estimates on a chromosome
res <- hsrecombi(hap, genotype.chr)
### post-processing to achieve final and valid set of estimates
final <- editraw(res, map.chr)
```

```
### approximation of genetic positions
pos <- geneticPosition(final, map.chr)
```

---

genotype.chr                    *targetregion: progeny genotypes*

---

### Description

matrix of progeny genotypes in target region on chromosome BTA1

### Usage

```
genotype.chr
```

### Format

An object of class `matrix` (inherits from `array`) with 265 rows and 200 columns.

---

haldane                        *Haldane's genetic map function*

---

### Description

Calculation of genetic distances from recombination rates

### Usage

```
haldane(x, inverse = F)
```

### Arguments

x	vector of recombination rates
inverse	logical, if FALSE recombination rate is mapped to Morgan unit, if TRUE Morgan unit is mapped to recombination rate (default is FALSE)

### Value

vector of genetic positions in Morgan units

### References

Haldane JBS (1919) The combination of linkage values, and the calculation of distances between the loci of linked factors. *J Genet* 8: 299-309.

### Examples

```
haldane(seq(0, 0.5, 0.01))
```

---

hapSire	<i>targetregion: sire haplotypes</i>
---------	--------------------------------------

---

**Description**

matrix of sire haplotypes in target region on chromosome BTA1

**Usage**

hapSire

**Format**

An object of class `matrix` (inherits from `array`) with 10 rows and 201 columns.

---

hsrecombi	<i>Estimation of recombination rate and maternal LD</i>
-----------	---

---

**Description**

Wrapper function for estimating recombination rate and maternal linkage disequilibrium between intra-chromosomal SNP pairs by calling EM algorithm

**Usage**

```
hsrecombi(hap, genotype.chr, exclude = NULL, only.adj = FALSE, prec = 1e-06)
```

**Arguments**

hap	list (LEN 2) of lists <b>famID</b> list (LEN number of sires) of vectors (LEN n.progeny) of progeny indices relating to lines in genotype matrix <b>sireHap</b> list (LEN number of sires) of matrices (DIM 2 x p) of sire haplotypes (0, 1) on investigated chromosome
genotype.chr	matrix (DIM n x p) of all progeny genotypes (0, 1, 2) on a chromosome with p SNPs; 9 indicates missing genotype
exclude	vector (LEN < p) of SNP IDs (for filtering column names of genotype.chr) to be excluded from analysis (default NULL)
only.adj	logical; if TRUE, recombination rate is calculated only between neighbouring markers
prec	scalar; precision of estimation

## Details

Paternal recombination rate and maternal linkage disequilibrium (LD) are estimated for pairs of biallelic markers (such as single nucleotide polymorphisms; SNPs) from progeny genotypes and sire haplotypes. At least one sire has to be double heterozygous at the investigated pairs of SNPs. All progeny are merged in two genomic families: (1) coupling phase family if sires are double heterozygous 0-0/1-1 and (2) repulsion phase family if sires are double heterozygous 0-1/1-0. So far it is recommended processing the chromosomes separately. If maternal half-sib families are used, the roles of sire/dam are swapped. Multiple families can be considered.

## Value

list (LEN p - 1) of data.frames; for each SNP, parameters are estimated with all following SNPs; two solutions (prefix sln1 and sln2) are obtained for two runs of the EM algorithm

SNP1 ID of 1. SNP

SNP2 ID of 2. SNP

D maternal LD

fAA frequency of maternal haplotype 1-1

fAB frequency of maternal haplotype 1-0

fBA frequency of maternal haplotype 0-1

fBB frequency of maternal haplotype 0-0

p1 Maternal allele frequency (allele 1) at SNP1

p2 Maternal allele frequency (allele 1) at SNP2

nfam1 size of genomic family 1

nfam2 size of genomic family 2

error 0 if computations were without error; 1 if EM algorithm did not converge

iteration number of EM iterations

theta paternal recombination rate

r2  $r^2$  of maternal LD

logL value of log likelihood function

unimodal 1 if likelihood is unimodal; 0 if likelihood is bimodal

critical 0 if parameter estimates are unique; 1 if parameter estimates at both solutions are valid, then decision process follows in post-processing function "editraw"

Afterwards, solutions are compared and processed with function `editraw`, yielding the final estimates for each valid pair of SNPs.

## References

- Hampel, A., Teuscher, F., Gomez-Raya, L., Doschoris, M. & Wittenburg, D. (2018) Estimation of recombination rate and maternal linkage disequilibrium in half-sibs. *Frontiers in Genetics* 9:186. [doi:10.3389/fgene.2018.00186](https://doi.org/10.3389/fgene.2018.00186)
- Gomez-Raya, L. (2012) Maximum likelihood estimation of linkage disequilibrium in half-sib families. *Genetics* 191:195-213.

**Examples**

```

### test data
data(targetregion)
### make list for paternal half-sib families
hap <- makehaplist(daughterSire, hapSire)
### parameter estimates on a chromosome
res <- hsrecombi(hap, genotype.chr)
### post-processing to achieve final and valid set of estimates
final <- editraw(res, map.chr)

```

---

karlin

*Liberman and Karlin's genetic map function*


---

**Description**

Calculation of genetic distances from recombination rates given a parameter

**Usage**

```
karlin(N, x, inverse = F)
```

**Arguments**

N	parameter (positive integer) required by the binomial model to assess the count (of crossover) distribution; N = 1 corresponds to Morgan's map function
x	vector of recombination rates
inverse	logical, if FALSE recombination rate is mapped to Morgan unit, if TRUE Morgan unit is mapped to recombination rate (default is FALSE)

**Value**

vector of genetic positions in Morgan units

**References**

Liberman, U. & Karlin, S. (1984) Theoretical models of genetic map functions. *Theor Popul Biol* 25:331-346.

**Examples**

```
karlin(2, seq(0, 0.5, 0.01))
```

---

kosambi	<i>Kosambi's genetic map function</i>
---------	---------------------------------------

---

**Description**

Calculation of genetic distances from recombination rates

**Usage**

```
kosambi(x, inverse = F)
```

**Arguments**

x	vector of recombination rates
inverse	logical, if FALSE recombination rate is mapped to Morgan unit, if TRUE Morgan unit is mapped to recombination rate (default is FALSE)

**Value**

vector of genetic positions in Morgan units

**References**

Kosambi D.D. (1944) The estimation of map distance from recombination values. Ann. Eugen. 12: 172-175.

**Examples**

```
kosambi(seq(0, 0.5, 0.01))
```

---

LDHScpp	<i>Expectation Maximisation (EM) algorithm</i>
---------	--

---

**Description**

Expectation Maximisation (EM) algorithm

**Usage**

```
LDHScpp(XGF1, XGF2, fAA, fAB, fBA, theta, display, threshold)
```

**Arguments**

XGF1	integer matrix of progeny genotypes in genomic family 1
XGF2	integer matrix of progeny genotypes in genomic family 2
fAA	frequency of maternal haplotype 1-1
fAB	frequency of maternal haplotype 1-0
fBA	frequency of maternal haplotype 0-1
theta	paternal recombination rate
display	logical for displaying additional information
threshold	convergence criterion

**Value**

list of parameter estimates

D maternal LD

fAA frequency of maternal haplotype 1-1

fAB frequency of maternal haplotype 1-0

fBA frequency of maternal haplotype 0-1

fBB frequency of maternal haplotype 0-0

p1 Maternal allele frequency (allele 1) at 1. SNP

p2 Maternal allele frequency (allele 1) at 2. SNP

nfam1 size of genomic family 1

nfam2 size of genomic family 2

error 0 if computations were without error; 1 if EM algorithm did not converge

iteration number of EM iterations

theta paternal recombination rate

r2  $r^2$  of maternal LD

logL value of log likelihood function

---

loglikfun

*Calculate log-likelihood function*


---

**Description**

Calculate log-likelihood function

**Arguments**

counts	integer vector of observed 2-locus genotype
fAA	frequency of maternal haplotype 1-1
fAB	frequency of maternal haplotype 1-0
fBA	frequency of maternal haplotype 0-1
fBB	frequency of maternal haplotype 0-0
theta	paternal recombination rate

**Value**

lik value of log likelihood at parameter estimates

---

makehap	<i>Make list of imputed sire haplotypes</i>
---------	---

---

**Description**

List of sire haplotypes is set up in the format required for hsrecombi. Sire haplotypes are imputed from progeny genotypes using R package hspbase.

**Usage**

```
makehap(sireID, daughterSire, genotype.chr, nmin = 30, exclude = NULL)
```

**Arguments**

sireID	vector (LEN N) of IDs of all sires
daughterSire	vector (LEN n) of sire ID for each progeny
genotype.chr	matrix (DIM n x p) of progeny genotypes (0, 1, 2) on a single chromosome with p SNPs; 9 indicates missing genotype
nmin	scalar, minimum required number of progeny for proper imputation, default 30
exclude	vector (LEN < p) of SNP indices to be excluded from analysis

**Value**

list (LEN 2) of lists. For each sire:

famID list (LEN N) of vectors (LEN n.progeny) of progeny indices relating to lines in genotype matrix

sireHap list (LEN N) of matrices (DIM 2 x p) of sire haplotypes (0, 1) on investigated chromosome

**References**

Ferdosi, M., Kinghorn, B., van der Werf, J., Lee, S. & Gondro, C. (2014) hspbase: an R package for pedigree reconstruction, detection of recombination events, phasing and imputation of half-sib family groups BMC Bioinformatics 15:172. <https://CRAN.R-project.org/package=hspbase>

**Examples**

```
data(targetregion)
hap <- makehap(unique(daughterSire), daughterSire, genotype.chr)
```

---

makehaplist	<i>Make list of sire haplotypes</i>
-------------	-------------------------------------

---

**Description**

List of sire haplotypes is set up in the format required for hsrecombi. Haplotypes (obtained by external software) are provided.

**Usage**

```
makehaplist(daughterSire, hapSire, nmin = 1)
```

**Arguments**

daughterSire	vector (LEN n) of sire ID for each progeny
hapSire	matrix (DIM 2N x p + 1) of sire haplotype at p SNPs; 2 lines per sire, 1. column contains sire ID
nmin	scalar, minimum number of progeny required, default 1

**Value**

list (LEN 2) of lists. For each sire:

famID list (LEN N) of vectors (LEN n.progeny) of progeny indices relating to lines in genotype matrix

sireHap list (LEN N) of matrices (DIM 2 x p) of sire haplotypes (0, 1) on investigated chromosome

**Examples**

```
data(targetregion)
hap <- makehaplist(daughterSire, hapSire)
```

---

makehappm	<i>Make list of imputed haplotypes and estimate recombination rate</i>
-----------	--

---

### Description

List of sire haplotypes is set up in the format required for `hsrecombi`. Sire haplotypes are imputed from progeny genotypes using R package `hsphase`. Furthermore, recombination rate estimates between adjacent SNPs from `hsphase` are reported.

### Usage

```
makehappm(sireID, daughterSire, genotype.chr, nmin = 30, exclude = NULL)
```

### Arguments

<code>sireID</code>	vector (LEN N) of IDs of all sires
<code>daughterSire</code>	vector (LEN n) of sire ID for each progeny
<code>genotype.chr</code>	matrix (DIM n x p) of progeny genotypes (0, 1, 2) on a single chromosome with p SNPs; 9 indicates missing genotype
<code>nmin</code>	scalar, minimum required number of progeny for proper imputation, default 30
<code>exclude</code>	vector (LEN < p) of SNP IDs (for filtering column names of <code>genotype.chr</code> ) to be excluded from analysis

### Value

list (LEN 2) of lists. For each sire:

**famID** list (LEN N) of vectors (LEN n.progeny) of progeny indices relating to lines in genotype matrix

**sireHap** list (LEN N) of matrices (DIM 2 x p) of sire haplotypes (0, 1) on investigated chromosome

**probRec** vector (LEN p - 1) of proportion of recombinant progeny over all families between adjacent SNPs

**numberRec** list (LEN N) of vectors (LEN n.progeny) of number of recombination events per animal

**gen** vector (LEN p) of genetic positions of SNPs (in cM)

### References

Ferdosi, M., Kinghorn, B., van der Werf, J., Lee, S. & Gondro, C. (2014) `hsphase`: an R package for pedigree reconstruction, detection of recombination events, phasing and imputation of half-sib family groups *BMC Bioinformatics* 15:172. <https://CRAN.R-project.org/package=hsphase>

### Examples

```
data(targetregion)
hap <- makehappm(unique(daughterSire), daughterSire, genotype.chr, exclude = paste0('V', 301:310))
```

---

map.chr	<i>targetregion: physical map</i>
---------	-----------------------------------

---

**Description**

SNP marker map in target region on chromosome BTA1 according to ARS-UCD1.2

**Usage**

map.chr

**Arguments**

map.chr	data frame
<b>SNP</b>	SNP index
<b>Chr</b>	chromosome of SNP
<b>locus_bp</b>	physical position of SNP in bp
<b>locus_Mb</b>	physical position of SNP in Mbp
<b>markername</b>	official SNP name

**Format**

An object of class `data.frame` with 200 rows and 6 columns.

---

rao	<i>System of genetic-map functions</i>
-----	--

---

**Description**

Calculation of genetic distances from recombination rates given a mixing parameter

**Usage**

rao(p, x, inverse = F)

**Arguments**

p	mixing parameter (see details); $0 \leq p \leq 1$
x	vector of recombination rates
inverse	logical, if FALSE recombination rate is mapped to Morgan unit, if TRUE Morgan unit is mapped to recombination rate (default is FALSE)

**Details**

Mixing parameter  $p=0$  would match to Morgan,  $p=0.25$  to Carter,  $p=0.5$  to Kosambi and  $p=1$  to Haldane map function. As an inverse of Rao's system of functions does not exist, NA will be produced if `inverse = T`. To approximate the inverse call function `rao.inv(p, x)`.

**Value**

vector of genetic positions in Morgan units

**References**

Rao, D.C., Morton, N.E., Lindsten, J., Hulten, M. & Yee, S (1977) A mapping function for man. *Human Heredity* 27: 99-104. doi:10.1159/000152856

**Examples**

```
rao(0.25, seq(0, 0.5, 0.01))
```

---

rao inverse

*Approximation to inverse of Rao's system of map functions*

---

**Description**

Calculation of recombination rates from genetic distances given a mixing parameter

**Usage**

```
rao.inv(p, x)
```

**Arguments**

p	mixing parameter (see details); $0 \leq p \leq 1$
x	vector in Morgan units

**Details**

Mixing parameter  $p=0$  would match to Morgan,  $p=0.25$  to Carter,  $p=0.5$  to Kosambi and  $p=1$  to Haldane map function.

**Value**

vector of recombination rates

**References**

Rao, D.C., Morton, N.E., Lindsten, J., Hulten, M. & Yee, S (1977) A mapping function for man. *Human Heredity* 27: 99-104. doi:10.1159/000152856

**Examples**

```
rao.inv(0.25, seq(0, 0.1, 0.1))
```

---

startvalue	<i>Start value for maternal allele and haplotype frequencies</i>
------------	--

---

**Description**

Determine default start values for Expectation Maximisation (EM) algorithm that is used to estimate paternal recombination rate and maternal haplotype frequencies

**Usage**

```
startvalue(Fam1, Fam2, Dd = 0, prec = 1e-06)
```

**Arguments**

Fam1	matrix (DIM n.progeny x 2) of progeny genotypes (0, 1, 2) of genomic family with coupling phase sires (1) at SNP pair
Fam2	matrix (DIM n.progeny x 2) of progeny genotypes (0, 1, 2) of genomic family with repulsion phase sires (2) at SNP pair
Dd	maternal LD, default 0
prec	minimum accepted start value for fAA, fAB, fBA; default 1e-6

**Value**

list (LEN 8)

fAA.start frequency of maternal haplotype 1-1

fAB.start frequency of maternal haplotype 1-0

fBA.start frequency of maternal haplotype 0-1

p1 estimate of maternal allele frequency (allele 1) when sire is heterozygous at SNP1

p2 estimate of maternal allele frequency (allele 1) when sire is heterozygous at SNP2

L1 lower bound of maternal LD

L2 upper bound for maternal LD

critical 0 if parameter estimates are unique; 1 if parameter estimates at both solutions are valid

**Examples**

```
n1 <- 100
n2 <- 20
G1 <- matrix(ncol = 2, nrow = n1, sample(c(0:2), replace = TRUE,
size = 2 * n1))
G2 <- matrix(ncol = 2, nrow = n2, sample(c(0:2), replace = TRUE,
size = 2 * n2))
startvalue(G1, G2)
```

---

targetregion	<i>Description of the targetregion data set</i>
--------------	---

---

### Description

The data set contains sire haplotypes, assignment of progeny to sire, progeny genotypes and physical map information in a target region

The raw data can be downloaded at the source given below. Then, executing the following R code leads to the data provided in `targetregion.RData`.

`hapSire` matrix of sire haplotypes of each sire; 2 lines per sire; 1. column contains sireID

`daughterSire` vector of sire ID for each progeny

`genotype.chr` matrix of progeny genotypes

`map.chr` SNP marker map in target region

### Source

The data are available at RADAR [doi:10.22000/280](https://doi.org/10.22000/280)

### Examples

```
## Not run:
# download data from RADAR (requires about 1.4 GB)
url <- "https://www.radar-service.eu/radar-backend/archives/fqSPQoIvjtoGJlav/versions/1/content"
curl_download(url = url, 'tmp.tar')
untar('tmp.tar')
file.remove('tmp.tar')
path <- '10.22000-280/data/dataset'
## list of haplotypes of sires for each chromosome
load(file.path(path, 'sire_haplotypes.RData'))
## assign progeny to sire
daughterSire <- read.table(file.path(path, 'assign_to_family.txt'))[, 1]
## progeny genotypes
X <- as.matrix(read.table(file.path(path, 'XFam-ARS.txt')))
## physical and approximated genetic map
map <- read.table(file.path(path, 'map50K_ARS_reordered.txt'), header = T)
## select target region
chr <- 1
window <- 301:500
## map information of target region
map.chr <- map[map$Chr == chr, ][window, ]
## matrix of sire haplotypes in target region
hapSire <- rlist::list.rbind(haps[[chr]])
sireID <- 1:length(unique(daughterSire))
hapSire <- cbind(rep(sireID, each = 2), hapSire[, window])
## matrix of progeny genotypes
genotype.chr <- X[, map.chr$SNP]
colnames(genotype.chr) <- map.chr$SNP
colnames(hapSire) <- c('sireID', map.chr$SNP)
```

```
save(list = c('genotype.chr', 'hapSire', 'map.chr', 'daughterSire'),  
      file = 'targetregion.RData', compress = 'xz')
```

```
## End(Not run)
```

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