

Package ‘ggroups’

April 13, 2019

Title Pedigree and Genetic Groups

Version 1.2.0

Date 2019-04-13

Description Calculates additive genetic relationship matrix and its inverse, in matrix and tabular-sparse formats. It includes functions for checking and processing pedigree, as well as functions to calculate the matrix of genetic group contributions (Q), and adding those contributions to the genetic merit of animals (Quaas (1988) <doi:10.3168/jds.S0022-0302(88)79691-5>). Calculation of Q is computationally extensive. There are computationally optimized functions to calculate Q.

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LazyData true

URL <https://github.com/nilforooshan/ggroups>

BugReports <https://github.com/nilforooshan/ggroups/issues>

Suggests doParallel (>= 1.0.14), foreach (>= 1.4.4)

RoxygenNote 6.1.1

Encoding UTF-8

Repository CRAN

NeedsCompilation no

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gggroups-package	<i>Pedigree and genetic groups</i>
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Description

This package contains pedigree processing and analyzing functions, including functions for checking and renumbering the pedigree, making the pedigree relationship matrix and its inverse, in matrix and tabular formats, as well as functions related to genetic groups.

Details

First, it is recommended to check the pedigree data . frame with the pedcheck function. Pedigree relationship matrix and its inverse are fundamentals in the conventional and modern animal breeding. The concept of genetic groups stems from the fact that not all the unknown parents are of the same genetic level. The genetic group contribution matrix (**Q**) is required to weight and add genetic group effects (\hat{g}) to the genetic merit of animals (\hat{u}), which is equal to $\mathbf{Q}\hat{g} + \hat{u}$ (Quaas, 1988). Calculating **Q** is computationally challenging, and for large pedigree, large RAM and long computational time is required. Therefore, the functions qmatL and its parallel version, qmatXL are introduced. Overlap between sire and dam genetic groups is supported.

Author(s)

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References

Quaas, R. L. 1988. Additive Genetic Model with Groups and Relationships. J. Dairy Sci., 71:1338-1345. <doi:10.3168/jds.S0022-0302(88)79691-5>

buildA	<i>Relationship matrix A</i>
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Description

Builds the pedigree-based additive genetic relationship matrix.

Usage

```
buildA(ped)
```

Arguments

`ped` : data.frame with integer columns corresponding to ID, SIRE, DAM. Missing value is 0.

Value

Relationship matrix **A**

Examples

```
ped = data.frame(ID=1:6, SIRE=c(0,0,1,3,1,4), DAM=c(0,0,2,2,2,5))
buildA(ped)
```

gghead	<i>Append genetic groups to the pedigree</i>
--------	--

Description

This function appends parents that are not available in the first column of the pedigree, to the head of the pedigree, and sorts it. Given a pedigree with all missing parents replaced with the corresponding genetic groups, this functions appends genetic groups to the head of the pedigree.

Usage

```
gghead(ped)
```

Arguments

`ped` : data.frame with integer columns corresponding to ID, SIRE, DAM. Missing value is 0.

Details

Consider this simple pedigree:

```
3 0 0
4 3 0
6 4 5
5 0 0
```

First, unknown parents are replaced with the corresponding genetic groups.
Please note that unknown parent IDs should be smaller than progeny IDs.

```
3 1 2
4 3 2
6 4 5
5 1 2
```

Then, gghead is applied to this pedigree (see the example).

Value

Processed pedigree data.frame

Examples

```
ped = data.frame(ID=c(3,4,6,5), SIRE=c(1,3,4,1), DAM=c(2,2,5,2))
gghead(ped)
```

inb	<i>Inbreeding coefficient</i>
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Description

Calculates inbreeding coefficient for an individual.

Usage

```
inb(ped, id)
```

Arguments

- ped : data.frame with integer columns corresponding to ID, SIRE, DAM. Missing value is 0.
- id : Numeric ID of an individual

Value

Inb : Inbreeding coefficient of the individual

Examples

```
ped = data.frame(ID=1:7, SIRE=c(0,0,1,1,3,1,5), DAM=c(0,0,0,2,4,4,6))
inb(ped, 7)
```

mat2tab	<i>Matrix to tabular</i>
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Description

Converts matrix data to tabular data.

Usage

```
mat2tab(mat)
```

Arguments

mat : matrix

Value

tab : data.frame with 2 integer (IDs) and 1 numeric (values) columns.

Examples

```
ped = data.frame(ID=1:6, SIRE=c(0,0,1,3,1,4), DAM=c(0,0,2,2,2,5))
mat2tab(buildA(ped))
```

offspring	<i>Descendants of an individual per generation</i>
-----------	--

Description

Counts and collects progeny and phenotyped progeny of an individual in successive generations.

Usage

```
offspring(ped, id, pheno)
```

Arguments

ped : data.frame with columns corresponding to ID, SIRE, DAM. Missing value is 0.

id : The ID of the individual, for which the descendants to be extracted.

pheno : Vector of phenotyped individuals.

Value

prgn : list of progeny per generation.

prgn.ph : list of phenotyped progeny per generation.

Examples

```
ped = data.frame(V1 = 1:19,
  V2 = c(0,0,1,1,0,0,0,0,0,4,5,5,7,0,0,9,0,0,12),
  V3 = c(0,0,0,2,0,2,0,3,3,3,0,6,8,8,8,10,11,11,0))
pheno = 10:18
# Find progeny and phenotyped progeny of individual 1.
offspring(ped, 1, pheno)
# Find phenotyped progeny of individual 1, in the 2nd generation.
offspring(ped, 1, 10:18)$prgn.ph[[2]]
# If only interested in finding the progeny of individual 1:
offspring(ped, 1, c())$prgn
```

pedcheck

Basic pedigree checks

Description

Performs basic pedigree checks.

Usage

```
pedcheck(ped)
```

Arguments

ped : data.frame with integer columns corresponding to ID, SIRE, DAM. Missing value is 0.

Examples

```
set.seed(127)
ped = data.frame(ID=c(1:50,NA,0,1:3),
  SIRE=c(0, sample(c(0,10:25), 53, replace=TRUE), 51),
  DAM=c(0, NA, 52, sample(c(0,20:35), 52, replace=TRUE)))
pedcheck(ped)
```

peddown	<i>Downward pedigree extraction</i>
---------	-------------------------------------

Description

Extracts pedigree downward for one or a group of individuals to find their descendants

Usage

```
peddown(ped, parents)
```

Arguments

`ped` : data.frame with integer columns corresponding to ID, SIRE, DAM. Missing value is 0.

`parents` : Vector of individual ID(s), from which the new pedigree is being extracted.

Value

`newped` : Extracted pedigree data.frame

Examples

```
ped = data.frame(ID=1:6, SIRE=c(0,0,1,3,1,4), DAM=c(0,0,2,2,2,5))
peddown(ped, c(1,4))
```

pedup	<i>Upward pedigree extraction</i>
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Description

Extracts pedigree upward for one or a group of individuals to find their ascendants

Usage

```
pedup(ped, progeny)
```

Arguments

`ped` : data.frame with integer columns corresponding to ID, SIRE, DAM. Missing value is 0.

`progeny` : Vector of individual ID(s), from which the new pedigree is being extracted.

Value

newped : Extracted pedigree data.frame

Examples

```
ped = data.frame(ID=1:6, SIRE=c(0,0,1,3,1,4), DAM=c(0,0,2,2,2,5))
pedup(ped, c(1,4))
```

prunedped	<i>Pedigree pruning</i>
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Description

Pruning pedigree in two different modes (strict, loose)

Usage

```
prunedped(ped, pheno, mode)
```

Arguments

- ped : data.frame with integer columns corresponding to ID, SIRE, DAM. Missing value is 0.
- pheno : Vector of phenotyped individuals
- mode : strict or loose

Details

In strict pruning, individuals without progeny and phenotype are recursively deleted from the pedigree, and then individuals without known parent and without progeny (if any) are deleted. Therefore, all uninfluential individuals are deleted. The downside is that individuals without phenotype or phenotyped progeny cannot receive any genetic merit based on the information from their phenotyped relatives. In loose pruning, the pedigree is upward extracted for phenotyped individuals to thier founders, and then the pedigree is downward extracted from the founders.

Value

newped : Pruned pedigree data.frame

Examples

```
ped = data.frame(ID=1:7, SIRE=c(0,0,1,3,1,4,0), DAM=c(0,0,2,2,2,5,0))
pheno = c(1,4)
prunedped(ped, pheno, mode="strict")
prunedped(ped, pheno, mode="loose")
```

Qgpu	Vector $\mathbf{Qg} + \mathbf{u}$
------	-----------------------------------

Description

Adds genetic group contributions to the genetic merit of individuals.

Usage

```
Qgpu(Q, sol)
```

Arguments

- Q : The output matrix from qmat (for more details: ?qmat)
- sol : data.frame with 2 numeric columns corresponding to ID, EBV ($\hat{\mathbf{g}}, \hat{\mathbf{u}}$), where $\hat{\mathbf{g}}$ and $\hat{\mathbf{u}}$ are the genetic group and genetic merit solutions, respectively. The order of solutions must be the order of columns and the order of rows in matrix \mathbf{Q} .

Value

Vector of $\mathbf{Q}\hat{\mathbf{g}} + \hat{\mathbf{u}}$

Examples

```
ped = data.frame(ID=c(3,4,6,5), SIRE=c(1,3,4,1), DAM=c(2,2,5,2))
Q = qmat(gghead(ped))
ghat = c(0.1, -0.2)
uhat = seq(-1.5, 1.5, 1)
sol = data.frame(ID=1:6, EBV=c(ghat, uhat))
Qgpu(Q, sol)
```

qmat	Matrix \mathbf{Q}
------	---------------------

Description

Creates the genetic group contribution matrix.

Usage

```
qmat(ped2)
```

Arguments

- ped2 : The output data.frame from gghead (for more details: ?gghead)

Value**Q** matrix**Examples**

```
ped = data.frame(ID=c(3,4,6,5), SIRE=c(1,3,4,1), DAM=c(2,2,5,2))
ped2 = gghead(ped)
qmat(ped2)
```

qmatL

*Matrix **Q** for large pedigrees***Description**

Creates the genetic group contribution matrix for large pedigrees.

Usage

```
qmatL(ped2)
```

Arguments

ped2 : The output data.frame from gghead (for more details: ?gghead)

Details

Calculation of the genetic group contribution matrix for large pedigrees requires a lot of memory and time. This might not be possible on ordinary computers, using the function qmat. The function qmatL takes less RAM and time, making the calculation possible for ordinary computers.

Value**Q** matrix**Examples**

```
ped = data.frame(ID=c(3,4,6,5), SIRE=c(1,3,4,1), DAM=c(2,2,5,2))
ped2 = gghead(ped)
qmatL(ped2)
```

qmatXL

*Matrix **Q** for large pedigrees (parallel processing)***Description**

Creates the genetic group contribution matrix for large pedigrees, with parallel processing.

Usage

```
qmatXL(ped2, ncl)
```

Arguments

`ped2` : The output data.frame from gghead (for more details: ?gghead)
`ncl` : User defined number of nodes; if the number of user defined nodes is greater than the number of genetic groups, the number genetic groups is considered as the number of nodes.

Details

This function is the parallel version of qmatL. It requires foreach and doParallel packages.

Value

Q matrix

Examples

```
ped = data.frame(ID=c(3,4,6,5), SIRE=c(1,3,4,1), DAM=c(2,2,5,2))
ped2 = gghead(ped)
qmatXL(ped2, 2)
```

renum

*Pedigree renumbering***Description**

Renumbering pedigree to numerical IDs, so that progeny's ID is smaller than parents' IDs.

Usage

```
renum(ped)
```

Arguments

ped : data.frame with columns corresponding to ID, SIRE, DAM. Missing value is 0.

Value

newped : Pedigree data.frame with renumbered IDs.
xrf : Cross-reference data.frame with 2 columns for original and renumbered IDs.

Examples

```
ped = data.frame(ID=letters[1:6], SIRE=c(0,0,letters[c(1,3,1,4)]), DAM=c(0,0,letters[c(2,2,2,5)]))
renum(ped)$newped
renum(ped)$xrf
```

rg	<i>Genetic relationship coefficient</i>
----	---

Description

Calculates genetic relationship coefficient between two individuals.

Usage

```
rg(ped, id1, id2)
```

Arguments

ped : data.frame with integer columns corresponding to ID, SIRE, DAM. Missing value is 0.
id1 : Numeric ID of an individual
id2 : Numeric ID of an individual

Value

rG : Genetic relationship coefficient between the two individuals

Examples

```
ped = data.frame(ID=1:7, SIRE=c(0,0,1,1,3,1,5), DAM=c(0,0,0,2,4,4,6))
rg(ped, 5, 6)
```

tab2mat	<i>Tabular to matrix</i>
---------	--------------------------

Description

Converts tabular data to matrix data.

Usage

```
tab2mat(tab)
```

Arguments

tab : data.frame with 2 integer (IDs) and 1 numeric (values) columns.

Value

mat: matrix

Examples

```
ped = data.frame(ID=1:6, SIRE=c(0,0,1,3,1,4), DAM=c(0,0,2,2,2,5))
tab2mat(tabA(ped))
```

tabA	<i>Relationship matrix A in a tabular format</i>
------	---

Description

Creates the pedigree-based additive genetic relationship data.frame.

Usage

```
tabA(ped)
```

Arguments

ped : data.frame with integer columns corresponding to ID, SIRE, DAM. Missing value is 0.

Value

Genetic relationship data.frame

Examples

```
ped = data.frame(ID=1:6, SIRE=c(0,0,1,3,1,4), DAM=c(0,0,2,2,2,5))
tabA(ped)
```

tabAinv

*Inverse of the relationship matrix **A** in a tabular format*

Description

Creates the `data.frame` of the inverse of the pedigree-based genetic relationship matrix.

Usage

```
tabAinv(ped, inbr)
```

Arguments

`ped` : `data.frame` with integer columns corresponding to ID, SIRE, DAM. Missing value is 0.

`inbr` : Vector of inbreeding coefficients in the order of individuals in the relationship matrix.

Value

`data.frame` of the inverse of the genetic relationship matrix

Examples

```
ped = data.frame(ID=1:6, SIRE=c(0,0,1,3,1,4), DAM=c(0,0,2,2,2,5))
inbr = c(0, 0, 0, 0.25, 0, 0.25)
# or
(inbr = diag(buildA(ped)) - 1)
# or
inbr = tabA(ped); (inbr[inbr[,1]==inbr[,2],]$a - 1)
# or
# For individual inbreeding values, use function inb.
tabAinv(ped, inbr)
```

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