# Package ‘AlphaSimR’

May 14, 2021

<table>
<thead>
<tr>
<th>Type</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Breeding Program Simulations</td>
</tr>
<tr>
<td>Version</td>
<td>1.0.1</td>
</tr>
<tr>
<td>Date</td>
<td>2021-05-14</td>
</tr>
</tbody>
</table>

**Description**  The successor to the 'AlphaSim' software for breeding program simulation [Faux et al. (2016) <doi:10.3835/plantgenome2016.02.0013>]. Used for stochastic simulations of breeding programs to the level of DNA sequence for every individual. Contained is a wide range of functions for modeling common tasks in a breeding program, such as selection and crossing. These functions allow for constructing simulations of highly complex plant and animal breeding programs via scripting in the R software environment. Such simulations can be used to evaluate overall breeding program performance and conduct research into breeding program design, such as implementation of genomic selection. Included is the 'Markovian Coalescent Simulator' ('MaCS') for fast simulation of biallelic sequences according to a population demographic history [Chen et al. (2009) <doi:10.1101/gr.083634.108>].

**License**  MIT + file LICENSE

**URL**  https://github.com/gaynorr/AlphaSimR

**Encoding**  UTF-8

**Depends**  R (>= 3.3.0), methods, R6

**Imports**  Rcpp (>= 0.12.7)

**LinkingTo**  Rcpp, RcppArmadillo (>= 0.7.500.0.0), BH

**RoxygenNote**  7.1.1

**Suggests**  knitr, rmarkdown, testthat

**VignetteBuilder**  knitr

**NeedsCompilation**  yes

**Author**  Chris Gaynor [aut, cre] (<https://orcid.org/0000-0003-0558-6656>), Gregor Gorjanec [ctb] (<https://orcid.org/0000-0001-8008-2787>), John Hickey [ctb] (<https://orcid.org/0000-0001-5675-3974>), Daniel Money [ctb] (<https://orcid.org/0000-0001-5151-3648>), David Wilson [ctb]
Maintainer  Chris Gaynor <gaynor.robert@hotmail.com>
Repository  CRAN
Date/Publication  2021-05-14 16:52:12 UTC

R topics documented:

aa .................................................. 4
attrition ........................................... 5
bv .................................................... 5
calcGCA ............................................ 6
cChr ............................................... 7
dd ................................................... 7
doubleGenome ..................................... 8
ebv .................................................. 9
editGenome ....................................... 10
editGenomeTopQtl ................................. 11
fastRRBLUP ...................................... 12
genicVarA ......................................... 13
genicVarAA ....................................... 14
genicVarD ......................................... 14
genicVarG ......................................... 15
genParam .......................................... 16
getQtlMap .......................................... 17
getSnpmMap ....................................... 18
gv .................................................. 19
hybridCross ...................................... 20
HybridPop-class ................................. 21
LociMap-class ..................................... 22
makeCross ........................................ 22
makeCross2 ....................................... 23
makeDH ............................................ 24
MapPop-class ..................................... 25
meanG ............................................. 25
meanP ............................................. 26
MegaPop-class ................................... 27
mergeGenome ...................................... 27
mergePops ........................................ 28
mutate ............................................ 29
NamedMapPop-class .............................. 30
newMapPop ........................................ 31
newMegaPop ...................................... 32
newPop ........................................... 32
nInd ............................................... 33
pedigreeCross .................................... 34
pheno ............................................. 35
Pop-class ........................................ 36
popVar .......................................... 37
<table>
<thead>
<tr>
<th>R topic documented</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>pullIbdHaplo</td>
<td>38</td>
</tr>
<tr>
<td>pullQtlGeno</td>
<td>38</td>
</tr>
<tr>
<td>pullQtlHaplo</td>
<td>39</td>
</tr>
<tr>
<td>pullSegSiteGeno</td>
<td>40</td>
</tr>
<tr>
<td>pullSegSiteHaplo</td>
<td>41</td>
</tr>
<tr>
<td>pullSnpGeno</td>
<td>42</td>
</tr>
<tr>
<td>pullSnpHaplo</td>
<td>42</td>
</tr>
<tr>
<td>quickHaplo</td>
<td>43</td>
</tr>
<tr>
<td>randCross</td>
<td>44</td>
</tr>
<tr>
<td>randCross2</td>
<td>45</td>
</tr>
<tr>
<td>RawPop-class</td>
<td>46</td>
</tr>
<tr>
<td>reduceGenome</td>
<td>47</td>
</tr>
<tr>
<td>resetPop</td>
<td>48</td>
</tr>
<tr>
<td>RRBLUP</td>
<td>49</td>
</tr>
<tr>
<td>RRBLUP2</td>
<td>50</td>
</tr>
<tr>
<td>RRBLUPMemUse</td>
<td>52</td>
</tr>
<tr>
<td>RRBLUP_D</td>
<td>53</td>
</tr>
<tr>
<td>RRBLUP_D2</td>
<td>54</td>
</tr>
<tr>
<td>RRBLUP_GCA</td>
<td>56</td>
</tr>
<tr>
<td>RRBLUP_GCA2</td>
<td>57</td>
</tr>
<tr>
<td>RRBLUP_SCA</td>
<td>59</td>
</tr>
<tr>
<td>RRBLUP_SCA2</td>
<td>60</td>
</tr>
<tr>
<td>RRsol-class</td>
<td>62</td>
</tr>
<tr>
<td>runMacs</td>
<td>62</td>
</tr>
<tr>
<td>runMacs2</td>
<td>63</td>
</tr>
<tr>
<td>sampleHaplo</td>
<td>65</td>
</tr>
<tr>
<td>selectCross</td>
<td>66</td>
</tr>
<tr>
<td>selectFam</td>
<td>67</td>
</tr>
<tr>
<td>selectInd</td>
<td>69</td>
</tr>
<tr>
<td>selectOP</td>
<td>70</td>
</tr>
<tr>
<td>selectWithinFam</td>
<td>71</td>
</tr>
<tr>
<td>self</td>
<td>73</td>
</tr>
<tr>
<td>selIndex</td>
<td>74</td>
</tr>
<tr>
<td>selInt</td>
<td>75</td>
</tr>
<tr>
<td>setEBV</td>
<td>75</td>
</tr>
<tr>
<td>setPheno</td>
<td>76</td>
</tr>
<tr>
<td>setPhenoGCA</td>
<td>78</td>
</tr>
<tr>
<td>setPhenoProgTest</td>
<td>79</td>
</tr>
<tr>
<td>SimParam</td>
<td>81</td>
</tr>
<tr>
<td>smithHazel</td>
<td>102</td>
</tr>
<tr>
<td>TraitA-class</td>
<td>102</td>
</tr>
<tr>
<td>TraitA2-class</td>
<td>103</td>
</tr>
<tr>
<td>TraitA2D-class</td>
<td>103</td>
</tr>
<tr>
<td>TraitAD-class</td>
<td>103</td>
</tr>
<tr>
<td>TraitADE-class</td>
<td>103</td>
</tr>
<tr>
<td>TraitADEG-class</td>
<td>104</td>
</tr>
<tr>
<td>TraitADG-class</td>
<td>104</td>
</tr>
<tr>
<td>TraitAE-class</td>
<td>104</td>
</tr>
</tbody>
</table>
Description

Returns additive-by-additive epistatic deviations for all traits

Usage

\texttt{aa(pop, simParam = NULL)}

Arguments

- \texttt{pop}  
  an object of \texttt{Pop-class}
- \texttt{simParam}  
  an object of \texttt{SimParam}

Examples

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

# Create population
pop = newPop(founderPop, simParam=SP)
aa(pop, simParam=SP)
```
attrition

Description
Samples individuals at random to remove from the population. The user supplies a probability for the individuals to be removed from the population.

Usage
attrition(pop, p)

Arguments
pop an object of Pop-class
p the expected proportion of individuals that will be lost to attrition.

Value
an object of Pop-class

Examples
#Create founder haplotypes
founderPop = quickHaplo(nInd=100, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)

#Create population
pop = newPop(founderPop, simParam=SP)

#Lose an expected 5% of individuals
pop = attrition(pop, p=0.05)

---

bv

Breeding value

Description
Returns breeding values for all traits

Usage
bv(pop, simParam = NULL)
Arguments

- `pop` an object of **Pop-class**
- `simParam` an object of **SimParam**

Examples

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)
```

---

**calcGCA**  
*Calculate GCA*

**Description**

Calculate general combining ability of test crosses. Intended for output from hybridCross using the "testcross" option, but will work for any population.

**Usage**

```r
calcGCA(pop, use = "pheno")
```

**Arguments**

- `pop` an object of **Pop-class** or **HybridPop-class**
- `use` tabulate either genetic values "gv", estimated breeding values "ebv", or phenotypes "pheno"

**Examples**

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10, inbred=TRUE)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)
```
# Make crosses for full diallele
pop2 = hybridCross(pop, pop, simParam=SP)
GCA = calcGCA(pop2, use="gv")

---

**cChr**  
*Combine MapPop chromosomes*

**Description**

Merges the chromosomes of multiple `MapPop-class` or `NamedMapPop-class` objects. Each MapPop must have the same number of chromosomes.

**Usage**

cChr(...)

**Arguments**

...  
`MapPop-class` or `NamedMapPop-class` objects to be combined

**Value**

Returns an object of `MapPop-class`.

**Examples**

pop1 = quickHaplo(nInd=10, nChr=1, segSites=10)
pop2 = quickHaplo(nInd=10, nChr=1, segSites=10)
combinedPop = cChr(pop1, pop2)

---

**dd**  
*Dominance deviations*

**Description**

Returns dominance deviations for all traits.

**Usage**

dd(pop, simParam = NULL)
 Arguments

  pop  an object of Pop-class
  simParam  an object of SimParam

 Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)
dd(pop, simParam=SP)

doubleGenome

 Double the ploidy of individuals

 Description

 Creates new individuals with twice the ploidy. This function was created to model the formation of
tetraploid potatoes from diploid potatoes. This function will work on any population.

 Usage

doubleGenome(pop, keepParents = TRUE, simParam = NULL)

 Arguments

  pop  an object of `Pop` superclass
  keepParents  should previous parents be used for mother and father.
  simParam  an object of `SimParam` class

 Value

 Returns an object of Pop-class
Examples

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)

# Create population
pop = newPop(founderPop, simParam=SP)

# Create individuals with doubled ploidy
pop2 = doubleGenome(pop, simParam=SP)
```

---

**ebv**

*Estimated breeding value*

Description

A wrapper for accessing the ebv slot

Usage

```r
ebv(pop)
```

Arguments

- `pop`: a **Pop-class** or similar object

Examples

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

# Create population
pop = newPop(founderPop, simParam=SP)
pop@ebv = matrix(rnorm(pop@nInd), nrow=pop@nInd, ncol=1)
ebv(pop)
```
editGenome

Description
Edits selected loci of selected individuals to a homozygous state for either the 1 or 0 allele. The gv slot is recalculated to reflect the any changes due to editing, but other slots remain the same.

Usage
editGenome(pop, ind, chr, segSites, allele, simParam = NULL)

Arguments
pop an object of Pop-class
ind a vector of individuals to edit
chr a vector of chromosomes to edit. Length must match length of segSites.
segSites a vector of segregating sites to edit. Length must match length of chr.
allele either 0 or 1 for desired allele
simParam an object of SimParam

Value
Returns an object of Pop-class

Examples
#Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

#Create population
pop = newPop(founderPop, simParam=SP)

#Change individual 1 to homozygous for the 1 allele
#at locus 1, chromosome 1
pop2 = editGenome(pop, ind=1, chr=1, segSites=1,
allele=1, simParam=SP)
**editGenomeTopQtl**  
*Edit genome - the top QTL*

### Description
Edits the top QTL (with the largest additive effect) to a homozygous state for the allele increasing. Only nonfixed QTL are edited. The gv slot is recalculated to reflect any changes due to editing, but other slots remain the same.

### Usage
```
editGenomeTopQtl(pop, ind, nQtl, trait = 1, increase = TRUE, simParam = NULL)
```

### Arguments
- **pop**: an object of Pop-class
- **ind**: a vector of individuals to edit
- **nQtl**: number of QTL to edit
- **trait**: which trait effects should guide selection of the top QTL
- **increase**: should the trait value be increased or decreased
- **simParam**: an object of SimParam

### Value
Returns an object of Pop-class

### Examples
```
# Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

# Create population
pop = newPop(founderPop, simParam=SP)

# Change up to 10 loci for individual 1
pop2 = editGenomeTopQtl(pop, ind=1, nQtl=10, simParam=SP)
```
**Description**

Solves an RR-BLUP model for genomic predictions given known variance components. This implementation is meant as a fast and low memory alternative to `RRBLUP` or `RRBLUP2`. Unlike the those functions, the fastRRBLUP does not fit fixed effects (other than the intercept) or account for unequal replication.

**Usage**

```r
fastRRBLUP(
  pop,
  traits = 1,
  use = "pheno",
  snpChip = 1,
  useQtl = FALSE,
  maxIter = 1000,
  Vu = NULL,
  Ve = NULL,
  simParam = NULL,
  ...
)
```

**Arguments**

- `pop` a `Pop-class` to serve as the training population
- `traits` an integer indicating the trait to model or a function of the traits returning a single value. Only univariate models are supported.
- `use` train model using phenotypes "pheno", genetic values "gv", estimated breeding values "ebv", breeding values "bv", or randomly "rand"
- `snpChip` an integer indicating which SNP chip genotype to use
- `useQtl` should QTL genotypes be used instead of a SNP chip. If TRUE, snpChip specifies which trait’s QTL to use, and thus these QTL may not match the QTL underlying the phenotype supplied in traits.
- `maxIter` maximum number of iterations.
- `Vu` marker effect variance. If value is NULL, a reasonable value is chosen automatically.
- `Ve` error variance. If value is NULL, a reasonable value is chosen automatically.
- `simParam` an object of `SimParam`
- `...` additional arguments if using a function for traits
Examples

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=20)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)
SP$addSnpChip(10)

# Create population
pop = newPop(founderPop, simParam=SP)

# Run GS model and set EBV
ans = fastRRBLUP(pop, simParam=SP)
pop = setEBV(pop, ans, simParam=SP)

# Evaluate accuracy
cor(gv(pop), ebv(pop))

genicVarA

Additive genic variance

Description

Returns additive genic variance for all traits

Usage

genicVarA(pop, simParam = NULL)

Arguments

pop an object of Pop-class
simParam an object of SimParam

Examples

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=20)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)
SP$addSnpChip(10)

# Create population
pop = newPop(founderPop, simParam=SP)
genicVarA(pop, simParam = SP)

genicVarAA  

Additive-by-additive genic variance

Description

Returns additive-by-additive epistatic genic variance for all traits

Usage

genicVarAA(pop, simParam = NULL)

Arguments

pop  
an object of Pop-class

simParam  
an object of SimParam

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)
geticVarAA(pop, simParam=SP)

---

genicVarD  

Dominance genic variance

Description

Returns dominance genic variance for all traits

Usage

genicVarD(pop, simParam = NULL)
genicVarG

**Arguments**

- `pop` an object of `Pop-class`
- `simParam` an object of `SimParam`

**Examples**

```r
code
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)
genicVarG(pop, simParam=SP)
```

---

**genicVarG**

*Total genic variance*

**Description**

Returns total genic variance for all traits

**Usage**

```r
genicVarG(pop, simParam = NULL)
```

**Arguments**

- `pop` an object of `Pop-class`
- `simParam` an object of `SimParam`

**Examples**

```r
code
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)
genicVarG(pop, simParam=SP)
```
### genParam

**Summarize genetic parameters**

#### Description

Calculates genetic and genic additive and dominance variances for an object of `Pop-class`

#### Usage

```r
genParam(pop, simParam = NULL)
```

#### Arguments

- **pop** an object of `Pop-class`
- **simParam** an object of `SimParam`

#### Value

- **varA** an nTrait by nTrait matrix of additive genetic variances
- **varD** an nTrait by nTrait matrix of dominance genetic variances
- **varAA** an nTrait by nTrait matrix of additive-by-additive genetic variances
- **varG** an nTrait by nTrait matrix of total genetic variances
- **genicVarA** an nTrait vector of additive genic variances
- **genicVarD** an nTrait vector of dominance genic variances
- **genicVarAA** an nTrait vector of additive-by-additive genic variances
- **genicVarG** an nTrait vector of total genic variances
- **covA_HW** an nTrait vector of additive covariances due to non-random mating
- **covD_HW** an nTrait vector of dominance covariances due to non-random mating
- **covAA_HW** an nTrait vector of additive-by-additive covariances due to non-random mating
- **covG_HW** an nTrait vector of total genic covariances due to non-random mating
- **covA_L** an nTrait vector of additive covariances due to linkage disequilibrium
- **covD_L** an nTrait vector of dominance covariances due to linkage disequilibrium
- **covAA_L** an nTrait vector of additive-by-additive covariances due to linkage disequilibrium
- **covAD_L** an nTrait vector of additive by dominance covariances due to linkage disequilibrium
- **covAAA_L** an nTrait vector of additive by additive-by-additive covariances due to linkage disequilibrium
- **covDAA_L** an nTrait vector of dominance by additive-by-additive covariances due to linkage disequilibrium
- **covG_L** an nTrait vector of total genic covariances due to linkage disequilibrium
- **mu** an nTrait vector of trait means
- **mu_HW** an nTrait vector of expected trait means under random mating
getQtlMap

gv  a matrix of genetic values with dimensions nInd by nTraits
bv  a matrix of breeding values with dimensions nInd by nTraits
dd  a matrix of dominance deviations with dimensions nInd by nTraits
aa  a matrix of additive-by-additive epistatic deviations with dimensions nInd by nTraits
gv_mu  an nTrait vector of intercepts with dimensions nInd by nTraits
gv_a  a matrix of additive genetic values with dimensions nInd by nTraits
gv_d  a matrix of dominance genetic values with dimensions nInd by nTraits
gv_aa a matrix of additive-by-additive genetic values with dimensions nInd by nTraits

Examples

#Create founder haplotypes
creatorPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)
an = genParam(pop, simParam=SP)

getQtlMap

Get QTL genetic map

Description

Retrieves the genetic map for the QTL of a given trait.

Usage

getQtlMap(trait = 1, sex = "A", simParam = NULL)

Arguments

trait  an integer for the
sex     determines which sex specific map is returned. Options are "A" for average map, "F" for female map, and "M" for male map. All options are equivalent if not using sex specific maps.
simParam an object of SimParam
Value

Returns a data.frame with:

- **id**  Unique identifier for the QTL
- **chr**  Chromosome containing the QTL
- **site**  Segregating site on the chromosome
- **pos**  Genetic map position

Examples

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(5)

# Pull SNP map
getQtlMap(trait=1, simParam=SP)
```

---

**getSnpMap**  
Get SNP genetic map

Description

Retrieves the genetic map for a given SNP chip.

Usage

```r
getSnpMap(snpChip = 1, sex = "A", simParam = NULL)
```

Arguments

- **snpChip**  an integer. Indicates which SNP chip’s map to retrieve.
- **sex**  determines which sex specific map is returned. Options are "A" for average map, "F" for female map, and "M" for male map. All options are equivalent if not using sex specific maps.
- **simParam**  an object of `SimParam`

Value

Returns a data.frame with:

- **id**  Unique identifier for the SNP
- **chr**  Chromosome containing the SNP
- **site**  Segregating site on the chromosome
- **pos**  Genetic map position
Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addSnpChip(5)

#Pull SNP map
getSnpMap(snpChip=1, simParam=SP)

_____________________

**gv**                      Genetic value
_____________________

Description

A wrapper for accessing the gv slot

Usage

`gv(pop)`

Arguments

pop a **Pop-class** or similar object

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)
gv(pop)
hybridCross  

**Description**

A convenience function for hybrid plant breeding simulations. Allows for easy specification of a test cross scheme and/or creation of an object of `HybridPop-class`. Note that the `HybridPop-class` should only be used if the parents were created using the `makeDH` function or `newPop` using inbred founders. The id for new individuals is `[mother_id][father_id]`

**Usage**

```r
hybridCross(
  females, 
  males, 
  crossPlan = "testcross", 
  returnHybridPop = FALSE, 
  simParam = NULL
)
```

**Arguments**

- `females` female population, an object of `Pop-class`
- `males` male population, an object of `Pop-class`
- `crossPlan` either "testcross" for all possible combinations or a matrix with two columns for designed crosses
- `returnHybridPop` should results be returned as `HybridPop-class`. If false returns results as `Pop-class`. Population must be fully inbred if TRUE.
- `simParam` an object of `SimParam`

**Examples**

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)

#Create population
pop = newPop(founderPop, simParam=SP)

#Make crosses for full diallele
pop2 = hybridCross(pop, pop, simParam=SP)
```
HybridPop-class

Hybrid population

Description

A lightweight version of Pop-class for hybrid lines. Memory is saved by not storing genotypic data.

Usage

```r
## S4 method for signature 'HybridPop'
x[i]
```

```r
## S4 method for signature 'HybridPop'
c(x, ...)
```

Arguments

- `x`: a 'HybridPop'
- `i`: index of individuals
- `...`: additional 'HybridPop' objects

Methods (by generic)

- `[]`: Extract HybridPop using index or id
- `c`: Combine multiple HybridPops

Slots

- `nInd`: number of individuals
- `id`: an individual’s identifier
- `mother`: the identifier of the individual’s mother
- `father`: the identifier of the individual’s father
- `nTraits`: number of traits
- `gv`: matrix of genetic values. When using GxE traits, `gv` reflects `gv` when `p=0.5`. Dimensions are `nInd` by `nTraits`.
- `pheno`: matrix of phenotypic values. Dimensions are `nInd` by `nTraits`.
- `gxe`: list containing GxE slopes for GxE traits
## LociMap-class

### Description

Loci metadata used for both SNPs and QTLs

### Slots

- `nLoci` total number of loci
- `lociPerChr` number of loci per chromosome
- `lociLoc` physical position of loci

## makeCross

### Description

Make designed crosses

### Usage

```r
makeCross(pop, crossPlan, nProgeny = 1, simParam = NULL)
```

### Arguments

- `pop`: an object of `Pop-class`
- `crossPlan`: a matrix with two column representing female and male parents. Either integers for the position in population or character strings for the IDs.
- `nProgeny`: number of progeny per cross
- `simParam`: an object of `SimParam`

### Value

Returns an object of `Pop-class`
### Examples

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)

# Create population
pop = newPop(founderPop, simParam=SP)

# Cross individual 1 with individual 10
crossPlan = matrix(c(1,10), nrow=1, ncol=2)
pop2 = makeCross(pop, crossPlan, simParam=SP)
```

---

### Description

Makes crosses between two populations using a user supplied crossing plan.

### Usage

```r
makeCross2(females, males, crossPlan, nProgeny = 1, simParam = NULL)
```

### Arguments

- **females**: an object of `Pop-class` for female parents.
- **males**: an object of `Pop-class` for male parents.
- **crossPlan**: a matrix with two column representing female and male parents. Either integers for the position in population or character strings for the IDs.
- **nProgeny**: number of progeny per cross
- **simParam**: an object of `SimParam`

### Value

Returns an object of `Pop-class`

### Examples

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
```
#Create population
crossPlan = matrix(c(1,10), nrow=1, ncol=2)
post2 = makeCross2(pop, pop, crossPlan, simParam=SP)

makeDH

Generates DH lines

Description

Creates DH lines from each individual in a population. Only works with diploid individuals. For polyploids, use `reduceGenome` and `doubleGenome`.

Usage

makeDH(pop, nDH = 1, useFemale = TRUE, keepParents = TRUE, simParam = NULL)

Arguments

- `pop` an object of 'Pop' superclass
- `nDH` total number of DH lines per individual
- `useFemale` should female recombination rates be used.
- `keepParents` should previous parents be used for mother and father.
- `simParam` an object of 'SimParam' class

Value

Returns an object of `Pop-class`

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)

#Create population
pop = newPop(founderPop, simParam=SP)

#Create 1 DH for each individual
pop2 = makeDH(pop, simParam=SP)
MapPop-class

Description

Extends RawPop-class to add a genetic map. This is the first object created in a simulation. It is used for creating initial populations and setting traits in the SimParam.

Usage

## S4 method for signature 'MapPop'

x[i]

## S4 method for signature 'MapPop'

c(x, ...)

Arguments

x a 'MapPop' object
i index of individuals
...
additional 'MapPop' objects

Methods (by generic)

- [: Extract MapPop by index
- c: Combine multiple MapPops

Slots

genMap "matrix" of chromosome genetic maps
centromere vector of centromere positions
inbred indicates whether the individuals are fully inbred

meanG Mean genetic values

Description

Returns the mean genetic values for all traits

Usage

meanG(pop)
**Arguments**

pop  an object of *Pop-class* or *HybridPop-class*

**Examples**

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)
meanP(pop)
```

---

**Description**

Returns the mean phenotypic values for all traits

**Usage**

```r
meanP(pop)
```

**Arguments**

pop  an object of *Pop-class* or *HybridPop-class*

**Examples**

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)
meanP(pop)
```
**Description**

The mega-population represents a population of populations. It is designed to behave like a list of populations.

**Usage**

```r
## S4 method for signature 'MegaPop'
x[i]

## S4 method for signature 'MegaPop'
x[[i]]

## S4 method for signature 'MegaPop'
c(x, ...)
```

**Arguments**

- `x`: a `MegaPop` object
- `i`: index of populations or mega-populations
- `...`: additional `MegaPop` or `Pop` objects

**Methods (by generic)**

- `[]`: Extract MegaPop by index
- `[[`: Extract Pop by index
- `c`: Combine multiple MegaPops

**Slots**

- `pops`: list of `Pop-class` and/or `MegaPop-class`

**Description**

This function is designed to model the pairing of gametes. The male and female individuals are treated as gametes, so the ploidy of newly created individuals will be the sum of it parents.
mergePops

Usage
mergeGenome(females, males, crossPlan, simParam = NULL)

Arguments
- females: an object of Pop-class for female parents.
- males: an object of Pop-class for male parents.
- crossPlan: a matrix with two column representing female and male parents. Either integers for the position in population or character strings for the IDs.
- simParam: an object of SimParam

Value
Returns an object of Pop-class

Examples
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)

#Create population
pop = newPop(founderPop, simParam=SP)

#Cross individual 1 with individual 10
crossPlan = matrix(c(1,10), nrow=1, ncol=2)
pop2 = mergeGenome(pop, pop, crossPlan, simParam=SP)

mergePops

Merge list of populations

Description
Rapidly merges a list of populations into a single population

Usage
mergePops(popList)

Arguments
- popList: a list containing Pop-class elements or a MegaPop-class
mutate

Value

Returns a Pop-class

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)

#Create a list of populations and merge list
pop = newPop(founderPop, simParam=SP)
popList = list(pop, pop)
pop2 = mergePops(popList)

mutate

Add Random Mutations

Description

Adds random mutations to individuals in a population. Note that any existing phenotypes or EBVs are kept. Thus, the user will need to run setPheno and/or setEBV to generate new phenotypes or EBVs that reflect changes introduced by the new mutations.

Usage

mutate(pop, mutRate = 2.5e-08, returnPos = FALSE, simParam = NULL)

Arguments

pop an object of Pop-class
mutRate rate of new mutations
returnPos should the positions of mutations be returned
simParam an object of SimParam

Value

an object of Pop-class if returnPos=FALSE or a list containing a Pop-class and a data.frame containing the postions of mutations if returnPos=TRUE
Examples

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

# Create population
pop = newPop(founderPop, simParam=SP)

# Introduce mutations
pop = mutate(pop, simParam=SP)
```

NamedMapPop-class

Raw population with genetic map and id

Description

Extends MapPop-class to add id, mother and father.

Usage

```r
## S4 method for signature 'NamedMapPop'
x[i]

## S4 method for signature 'NamedMapPop'
c(x, ...)
```

Arguments

- `x` a `NamedMapPop` object
- `i` index of individuals
- `...` additional `NamedMapPop` objects

Methods (by generic)

- `[`: Extract NamedMapPop by index
- `c`: Combine multiple NamedMapPops

Slots

- `id` an individual’s identifier
- `mother` the identifier of the individual’s mother
- `father` the identifier of the individual’s father
newMapPop

newMapPop  New MapPop

Description

Creates a new MapPop-class from user supplied genetic maps and haplotypes.

Usage

newMapPop(genMap, haplotypes, inbred = FALSE, ploidy = 2L)

Arguments

genMap  a list of genetic maps
haplotypes  a list of matrices or data.frames that can be coerced to matrices. See details.
inbred  are individuals fully inbred
ploidy  ploidy level of organism

Details

Each item of genMap must be a vector of ordered genetic lengths in Morgans. The first value must be zero. The length of the vector determines the number of segregating sites on the chromosome.

Each item of haplotypes must be coercible to a matrix. The columns of this matrix correspond to segregating sites and their number must match

Value

an object of MapPop-class

Examples

# Create genetic map for two chromosomes, each 1 Morgan long
# Each chromosome contains 11 equally spaced segregating sites
genMap = list(seq(0,1,length.out=11),
             seq(0,1,length.out=11))

# Create haplotypes for 10 outbred individuals
chr1 = sample(x=0:1,size=20*11,replace=TRUE)
chr1 = matrix(chr1,nrow=20,ncol=11)
chr2 = sample(x=0:1,size=20*11,replace=TRUE)
chr2 = matrix(chr2,nrow=20,ncol=11)
haplotypes = list(chr1,chr2)

founderPop = newMapPop(genMap=genMap, haplotypes=haplotypes)
newMegaPop  
Create new Mega Population

Description

Creates a new MegaPop-class from one or more Pop-class and/or MegaPop-class objects.

Usage

newMegaPop(...)

Arguments

... one or more Pop-class and/or MegaPop-class objects.

Value

Returns an object of MegaPop-class

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

#Create population
pop = newPop(founderPop, simParam=SP)
megaPop = newMegaPop(pop=pop)

newPop  
Create new Population

Description

Creates a new Pop-class from an object of MapPop-class or RawPop-class. The function is intended for creating initial populations from 'FOUNDERPPOP' created by runMacs.

Usage

newPop(rawPop, id = NULL, mother = NULL, father = NULL, simParam = NULL, ...)
**nInd**

**Arguments**

rawPop  
an object of `MapPop-class` or `RawPop-class`

id  
optional id for new individuals.

mother  
optional id for mothers.

father  
optional id for fathers.

simParam  
an object of `SimParam`

...  
additional arguments used internally

**Value**

Returns an object of `Pop-class`

**Examples**

```r
#Create founder haplotypes
defounderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

#Create population
dpop = newPop(founderPop, simParam=SP)
```

---

**nInd**  
*Number of individuals*

**Description**

A wrapper for accessing the nInd slot

**Usage**

```r
nInd(pop)
```

**Arguments**

pop  
a `Pop-class` or similar object
Examples

```r
#Create founder haplotypes
creator = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)
nInd(pop)
```

Description

Creates a `Pop-class` from a generic pedigree and a set of founder individuals.

The way in which the user supplied pedigree is used depends on the value of `matchID`. If `matchID` is `TRUE`, the IDs in the user supplied pedigree are matched against `founderNames`. If `matchID` is `FALSE`, founder individuals in the user supplied pedigree are randomly sampled from `founderPop`.

Usage

```r
deedee(Cross(  
founderPop,  
   id,  
   mother,  
   father,  
   matchID = FALSE,  
   maxCycle = 100,  
   DH = NULL,  
   useFemale = TRUE,  
   simParam = NULL  
)
```

Arguments

- `founderPop` a `Pop-class`
- `id` a vector of unique identifiers for individuals in the pedigree. The values of these IDs are separate from the IDs in the `founderPop` if `matchID=FALSE`.
- `mother` a vector of identifiers for the mothers of individuals in the pedigree. Must match one of the elements in the `id` vector or they will be treated as unknown.
- `father` a vector of identifiers for the fathers of individuals in the pedigree. Must match one of the elements in the `id` vector or they will be treated as unknown.
**matchID**  
indicates if the IDs in founderPop should be matched to the id argument. See details.

**maxCycle**  
the maximum number of loops to make over the pedigree to sort it.

**DH**  
an optional vector indicating if an individual should be made a doubled haploid.

**useFemale**  
If creating DH lines, should female recombination rates be used. This parameter has no effect if recombRatio=1.

**simParam**  
an object of `SimParam` class

### Examples

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)

#Create population
pop = newPop(founderPop, simParam=SP)

#Pedigree for a biparental cross with 7 generations of selfing
id = 1:10
mother = c(0,0,1,3:9)
father = c(0,0,2,3:9)
pop2 = pedigreeCross(pop, id, mother, father, simParam=SP)
```

---

### pheno

**Phenotype**

**Description**

A wrapper for accessing the pheno slot

**Usage**

```r
pheno(pop)
```

**Arguments**

- **pop**  
a `Pop-class` or similar object
Examples

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

# Create population
pop = newPop(founderPop, simParam=SP)
pheno(pop)

---

Pop-class

Population

Description

Extends RawPop-class to add sex, genetic values, phenotypes, and pedigrees.

Usage

## S4 method for signature 'Pop'
x[i]

## S4 method for signature 'Pop'
c(x, ...)

## S4 method for signature 'Pop'
show(object)

Arguments

x     a 'Pop' object
i     index of individuals
...   additional 'Pop' objects
object a 'Pop' object

Methods (by generic)

- [: Extract Pop by index or id
- c: Combine multiple Pops
- show: Show population summary
**popVar**

**Slots**
- **id**: an individual’s identifier
- **iid**: an individual’s internal identifier
- **mother**: the identifier of the individual’s mother
- **father**: the identifier of the individual’s father
- **sex**: sex of individuals: "M" for males, "F" for females, and "H" for hermaphrodites
- **nTraits**: number of traits
- **gv**: matrix of genetic values. When using GxE traits, gv reflects gv when p=0.5. Dimensions are nInd by nTraits.
- **pheno**: matrix of phenotypic values. Dimensions are nInd by nTraits.
- **ebv**: matrix of estimated breeding values. Dimensions are nInd rows and a variable number of columns.
- **gxe**: list containing GxE slopes for GxE traits
- **fixEff**: a fixed effect relating to the phenotype. Used by genomic selection models but otherwise ignored.
- **reps**: the number of replications used to measure the phenotype. Used by genomic selection models, but otherwise ignored.
- **misc**: a list whose elements correspond to individuals in the population. This list is normally empty and exists solely as an open slot available for uses to store extra information about individuals.

---

**popVar**

*Population variance*

**Description**

Calculates the population variance matrix as opposed to the sample variance matrix calculated by `var`. i.e. divides by n instead of n-1

**Usage**

`popVar(X)`

**Arguments**

- **X**: an n by m matrix

**Value**

an m by m variance-covariance matrix
pullIbdHaplo  

**Pull IBD haplotypes**

### Description
Retrieves IBD haplotype data

### Usage
```
pullIbdHaplo(pop, chr = NULL, simParam = NULL)
```

### Arguments
- `pop`: an object of `Pop-class`
- `chr`: a vector of chromosomes to retrieve. If NULL, all chromosome are retrieved.
- `simParam`: an object of `SimParam`

### Value
Returns a matrix of SNP haplotypes.

### Examples
```
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=15)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$addSnpChip(5)
SP$setTrackRec(TRUE)

#Create population
pop = newPop(founderPop, simParam=SP)
pullIbdHaplo(pop, simParam=SP)
```

pullQtlGeno  

**Pull QTL genotype**

### Description
Retrieves QTL genotype data

### Usage
```
pullQtlGeno(pop, trait = 1, chr = NULL, simParam = NULL)
```
pullQtlHaplo

**Description**

Retrieves QTL haplotype data

**Usage**

```
pullQtlHaplo(pop, trait = 1, haplo = "all", chr = NULL, simParam = NULL)
```

**Arguments**

- `pop` 
  - an object of `Pop-class`
- `trait` 
  - an integer. Indicates which trait’s QTL haplotypes to retrieve.
- `haplo` 
  - either "all" for all haplotypes or an integer for a single set of haplotypes. Use a value of 1 for female haplotypes and a value of 2 for male haplotypes.
- `chr` 
  - a vector of chromosomes to retrieve. If NULL, all chromosome are retrieved.
- `simParam` 
  - an object of `SimParam`
pullSegSiteGeno

Value

Returns a matrix of QTL haplotypes.

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=15)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$addSnpChip(5)

#Create population
pop = newPop(founderPop, simParam=SP)
pullQtlHaplo(pop, simParam=SP)

________________________
pullSegSiteGeno  Pull seg site genotypes
________________________

Description

Retrieves genotype data for all segregating sites

Usage

pullSegSiteGeno(pop, chr = NULL, simParam = NULL)

Arguments

pop  an object of Pop-class or RawPop-class
chr  a vector of chromosomes to retrieve. If NULL, all chromosome are retrieved.
simParam  an object of SimParam

Value

Returns a matrix of genotypes

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=15)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$addSnpChip(5)
#Create population
pop = newPop(founderPop, simParam=SP)
pullSegSiteGeno(pop, simParam=SP)

## pullSegSiteHaplo

### Pull seg site haplotypes

#### Description
Retrieves haplotype data for all segregating sites

#### Usage

```
pullSegSiteHaplo(pop, haplo = "all", chr = NULL, simParam = NULL)
```

#### Arguments

- **pop**: an object of `Pop-class` or `RawPop-class`
- **haplo**: either "all" for all haplotypes or an integer for a single set of haplotypes. Use a value of 1 for female haplotypes and a value of 2 for male haplotypes.
- **chr**: a vector of chromosomes to retrieve. If NULL, all chromosome are retrieved.
- **simParam**: an object of `SimParam`

#### Value
Returns a matrix of haplotypes

#### Examples

```
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=15)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$addSnpChip(5)

#Create population
pop = newPop(founderPop, simParam=SP)
pullSegSiteHaplo(pop, simParam=SP)
```
pullSnpGeno

**Pull SNP genotype**

**Description**

Retrieves SNP genotype data

**Usage**

```r
pullSnpGeno(pop, snpChip = 1, chr = NULL, simParam = NULL)
```

**Arguments**

- `pop`: an object of `Pop-class`
- `snpChip`: an integer. Indicates which SNP chip’s genotypes to retrieve.
- `chr`: a vector of chromosomes to retrieve. If NULL, all chromosome are retrieved.
- `simParam`: an object of `SimParam`

**Value**

Returns a matrix of SNP genotypes.

**Examples**

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=15)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$addSnpChip(5)

# Create population
pop = newPop(founderPop, simParam=SP)
pullSnpGeno(pop, simParam=SP)
```

---

pullSnpHaplo

**Pull SNP haplotypes**

**Description**

Retrieves SNP haplotype data

**Usage**

```r
pullSnpHaplo(pop, snpChip = 1, haplo = "all", chr = NULL, simParam = NULL)
```

**Examples**

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=15)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$addSnpChip(5)

# Create population
pop = newPop(founderPop, simParam=SP)
pullSnpHaplo(pop, snpChip = 1, haplo = "all")
```
Arguments

pop an object of Pop-class
snpChip an integer. Indicates which SNP chip’s haplotypes to retrieve.
haplo either "all" for all haplotypes or an integer for a single set of haplotypes. Use a value of 1 for female haplotypes and a value of 2 for male haplotypes.
chr a vector of chromosomes to retrieve. If NULL, all chromosome are retrieved.
simParam an object of SimParam

Value

Returns a matrix of SNP haplotypes.

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=15)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$addSnpChip(5)

#Create population
pop = newPop(founderPop, simParam=SP)
pullSnpHaplo(pop, simParam=SP)

---

quickHaplo Quick founder haplotype simulation

Description

Rapidly simulates founder haplotypes by randomly sampling 0s and 1s. This is equivalent to having all loci with allele frequency 0.5 and being in linkage equilibrium.

Usage

quickHaplo(nInd, nChr, segSites, genLen = 1, ploidy = 2L, inbred = FALSE)

Arguments

nInd number of individuals to simulate
nChr number of chromosomes to simulate
segSites number of segregating sites per chromosome
genLen genetic length of chromosomes
ploidy ploidy level of organism
inbred should founder individuals be inbred
Value

an object of MapPop-class

Examples

# Creates a populations of 10 outbred individuals
# Their genome consists of 1 chromosome and 100 segregating sites
founderPop = quickHaplo(nInd=10,nChr=1,segSites=100)

randCross

Make random crosses

Description

A wrapper for makeCross that randomly selects parental combinations for all possible combinations.

Usage

randCross(
  pop,
  nCrosses,
  nProgeny = 1,
  balance = TRUE,
  parents = NULL,
  ignoreSexes = FALSE,
  simParam = NULL
)

Arguments

pop an object of Pop-class
nCrosses total number of crosses to make
nProgeny number of progeny per cross
balance if using sexes, this option will balance the number of progeny per parent
parents an optional vector of indices for allowable parents
ignoreSexes should sexes be ignored
simParam an object of SimParam

Value

Returns an object of Pop-class
Examples

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)

# Create population
pop = newPop(founderPop, simParam=SP)

# Make 10 crosses
pop2 = randCross(pop, 10, simParam=SP)
```

---

**randCross2**  
*Make random crosses*

**Description**

A wrapper for `makeCross2` that randomly selects parental combinations for all possible combinations between two populations.

**Usage**

```r
randCross2(
  females,
  males,
  nCrosses,
  nProgeny = 1,
  balance = TRUE,
  femaleParents = NULL,
  maleParents = NULL,
  ignoreSexes = FALSE,
  simParam = NULL
)
```

**Arguments**

- **females**: an object of `Pop-class` for female parents.
- **males**: an object of `Pop-class` for male parents.
- **nCrosses**: total number of crosses to make
- **nProgeny**: number of progeny per cross
- **balance**: this option will balance the number of progeny per parent
- **femaleParents**: an optional vector of indices for allowable female parents
- **maleParents**: an optional vector of indices for allowable male parents
- **ignoreSexes**: should sex be ignored
- **simParam**: an object of `SimParam`
Value

Returns an object of `Pop-class`

Examples

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)

#Create population
pop = newPop(founderPop, simParam=SP)

#Make 10 crosses
pop2 = randCross2(pop, pop, 10, simParam=SP)
```

---

**RawPop-class**

*Raw Population*

Description

The raw population class contains only genotype data.

Usage

```r
## S4 method for signature 'RawPop'
\[ \text{x[i]} \]

## S4 method for signature 'RawPop'
\[ \text{c(x, \ldots)} \]

## S4 method for signature 'RawPop'
\[ \text{show(object)} \]
```

Arguments

- `x`: a `RawPop` object
- `i`: index of individuals
- `\ldots`: additional `RawPop` objects
- `object`: a `RawPop` object

Methods (by generic)

- `[]`: Extract RawPop by index
- `c`: Combine multiple RawPops
- `show`: Show population summary
reduceGenome

Slots

nInd  number of individuals
nChr  number of chromosomes
ploidy  level of ploidy
nLoci  number of loci per chromosome
genotypes  "matrix" containing chromosome genotypes. The "matrix" has dimensions nChr by 1 and each element is a three dimensional array of raw values. The array dimensions are nLoci by ploidy by nInd.

Description

Create individuals with reduced ploidy

Creates new individuals from gametes. This function was created to model the creation of diploid potatoes from tetraploid potatoes. It can be used on any population with an even ploidy level. The newly created individuals will have half the ploidy level of the originals. The reduction can occur with or without genetic recombination.

Usage

reduceGenome(
  pop,
  nProgeny = 1,
  useFemale = TRUE,
  keepParents = TRUE,
  simRecomb = TRUE,
  simParam = NULL
)

Arguments

pop  an object of `Pop` superclass
nProgeny  total number of progeny per individual
useFemale  should female recombination rates be used.
keepParents  should previous parents be used for mother and father.
simRecomb  should genetic recombination be modeled.
simParam  an object of `SimParam` class

Value

Returns an object of Pop-class
Examples

# Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)

# Create population
pop = newPop(founderPop, simParam=SP)

# Create individuals with reduced ploidy
pop2 = reduceGenome(pop, simParam=SP)

resetPop

Reset population

Description
Recalculates a population’s genetic values and resets phenotypes and EBVs.

Usage
resetPop(pop, simParam = NULL)

Arguments

pop an object of Pop-class
simParam an object of SimParam

Value
an object of Pop-class

Examples

# Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

# Create population
pop = newPop(founderPop, simParam=SP)

# Rescale to set mean to 1
SP$rescaleTraits(mean=1)
pop = resetPop(pop, simParam=SP)
Description

Fits an RR-BLUP model for genomic predictions.

Usage

RRBLUP(
  pop,
  traits = 1,
  use = "pheno",
  snpChip = 1,
  useQtl = FALSE,
  maxIter = 1000L,
  useReps = FALSE,
  simParam = NULL,
  ...
)

Arguments

pop a Pop-class to serve as the training population

traits an integer indicating the trait or traits to model, or a function of the traits returning a single value.

use train model using phenotypes "pheno", genetic values "gv", estimated breeding values "ebv", breeding values "bv", or randomly "rand"

snpChip an integer indicating which SNP chip genotype to use

useQtl should QTL genotypes be used instead of a SNP chip. If TRUE, snpChip specifies which trait's QTL to use, and thus these QTL may not match the QTL underlying the phenotype supplied in traits.

maxIter maximum number of iterations. Only used when number of traits is greater than 1.

useReps should population's reps slot be used to model heterogeneous error variance

simParam an object of SimParam

... additional arguments if using a function for traits

Examples

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=20)

# Set simulation parameters
SP = SimParam$new(founderPop)
RRBLUP2

RR-BLUP Model 2

Description

Fits an RR-BLUP model for genomic predictions. This implementation is meant for situations where RRBLUP is too slow. Note that RRBLUP2 is only faster in certain situations, see details below. Most users should use RRBLUP.

Usage

RRBLUP2(
  pop,
  traits = 1,
  use = "pheno",
  snpChip = 1,
  useQtl = FALSE,
  maxIter = 10,
  Vu = NULL,
  Ve = NULL,
  useEM = TRUE,
  tol = 1e-06,
  useReps = FALSE,
  simParam = NULL,
  ...
)

Arguments

pop a Pop-class to serve as the training population

traits an integer indicating the trait to model or a function of the traits returning a single value. Unlike RRBLUP, only univariate models are supported.
use train model using phenotypes "pheno", genetic values "gv", estimated breeding values "ebv", breeding values "bv", or randomly "rand"
snpChip an integer indicating which SNP chip genotype to use
useQtl should QTL genotypes be used instead of a SNP chip. If TRUE, snpChip specifies which trait’s QTL to use, and thus these QTL may not match the QTL underlying the phenotype supplied in traits.
maxIter maximum number of iterations.
Vu marker effect variance. If value is NULL, a reasonable starting point is chosen automatically.
Ve error variance. If value is NULL, a reasonable starting point is chosen automatically.
useEM use EM to solve variance components. If false, the initial values are considered true.
tol tolerance for EM algorithm convergence
useReps should population’s reps slot be used to model heterogeneous error variance
simParam an object of SimParam
... additional arguments if using a function for traits

Details

The RRBLUP2 function works best when the number of markers is not too large. This is because it solves the RR-BLUP problem by setting up and solving Henderson’s mixed model equations. Solving these equations involves a square matrix with dimensions equal to the number of fixed effects plus the number of random effects (markers). Whereas the RRBLUP function solves the RR-BLUP problem using the EMMA approach. This approach involves a square matrix with dimensions equal to the number of phenotypic records. This means that the RRBLUP2 function uses less memory than RRBLUP when the number of markers is approximately equal to or smaller than the number of phenotypic records.

The RRBLUP2 function is not recommend for cases where the variance components are unknown. This is uses the EM algorithm to solve for unknown variance components, which is generally considerably slower than the EMMA approach of RRBLUP. The number of iterations for the EM algorithm is set by maxIter. The default value is typically too small for convergence. When the algorithm fails to converge a warning is displayed, but results are given for the last iteration. These results may be "good enough". However we make no claim to this effect, because we can not generalize to all possible use cases.

The RRBLUP2 function can quickly solve the mixed model equations without estimating variance components. The variance components are set by defining Vu and Ve. Estimation of components is suppressed by setting useEM to false. This may be useful if the model is being retrained multiple times during the simulation. You could run RRBLUP function the first time the model is trained, and then use the variance components from this output for all future runs with the RRBLUP2 functions. Again, we can make no claim to the general robustness of this approach.

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=20)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)
SP$addSnpChip(10)

#Create population
pop = newPop(founderPop, simParam=SP)

#Run GS model and set EBV
ans = RRBLUP2(pop, simParam=SP)
pop = setEBV(pop, ans, simParam=SP)

#Evaluate accuracy
cor(gv(pop), ebv(pop))

<table>
<thead>
<tr>
<th>RRBLUPMemUse</th>
<th>RRBLUP Memory Usage</th>
</tr>
</thead>
</table>

**Description**

Estimates the amount of RAM needed to run the RRBLUP and its related functions for a given training population size. Note that this function may underestimate total usage.

**Usage**

RRBLUPMemUse(nInd, nMarker, model = "REG")

**Arguments**

- **nInd**: the number of individuals in the training population
- **nMarker**: the number of markers per individual
- **model**: either "REG", "GCA", or "SCA" for RRBLUP RRBLUP_GCA and RRBLUP_SCA respectively.

**Value**

Returns an estimate for the required gigabytes of RAM

**Examples**

RRBLUPMemUse(nInd=1000, nMarker=5000)
**RRBLUP_D**

**RR-BLUP Model with Dominance**

**Description**

Fits an RR-BLUP model for genomic predictions that includes dominance effects.

**Usage**

```r
RRBLUP_D(
  pop,
  traits = 1,
  use = "pheno",
  snpChip = 1,
  useQtl = FALSE,
  maxIter = 40L,
  useReps = FALSE,
  simParam = NULL,
  ...
)
```

**Arguments**

- **pop**
  - a **Pop-class** to serve as the training population
- **traits**
  - an integer indicating the trait to model, or a function of the traits returning a single value.
- **use**
  - train model using phenotypes "pheno", genetic values "gv", estimated breeding values "ebv", breeding values "bv", or randomly "rand"
- **snpChip**
  - an integer indicating which SNP chip genotype to use
- **useQtl**
  - should QTL genotypes be used instead of a SNP chip. If TRUE, snpChip specifies which trait's QTL to use, and thus these QTL may not match the QTL underlying the phenotype supplied in traits.
- **maxIter**
  - maximum number of iterations. Only used when number of traits is greater than 1.
- **useReps**
  - should population's reps slot be used to model heterogeneous error variance
- **simParam**
  - an object of **SimParam**
- **...**
  - additional arguments if using a function for traits

**Examples**

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=20)

#Set simulation parameters
SP = SimParam$new(founderPop)
```
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)
SP$addSnpChip(10)

# Create population
pop = newPop(founderPop, simParam=SP)

# Run GS model and set EBV
ans = RRBLUP_D(pop, simParam=SP)
pop = setEBV(pop, ans, simParam=SP)

# Evaluate accuracy
cor(gv(pop), ebv(pop))

---

**RRBLUP_D2**

*RR-BLUP with Dominance Model 2*

**Description**

Fits an RR-BLUP model for genomic predictions that includes dominance effects. This implementation is meant for situations where **RRBLUP_D** is too slow. Note that RRBLUP_D2 is only faster in certain situations. Most users should use **RRBLUP_D**.

**Usage**

```r
RRBLUP_D2(
  pop,
  traits = 1,
  use = "pheno",
  snpChip = 1,
  useQtl = FALSE,
  maxIter = 10,
  Va = NULL,
  Vd = NULL,
  Ve = NULL,
  useEM = TRUE,
  tol = 1e-06,
  useReps = FALSE,
  simParam = NULL,
  ...
)
```

**Arguments**

- **pop**  
  A *Pop-class* to serve as the training population

- **traits**  
  An integer indicating the trait to model, or a function of the traits returning a single value.
use train model using phenotypes "pheno", genetic values "gv", estimated breeding values "ebv", breeding values "bv", or randomly "rand"

snpChip an integer indicating which SNP chip genotype to use

useQtl should QTL genotypes be used instead of a SNP chip. If TRUE, snpChip specifies which trait’s QTL to use, and thus these QTL may not match the QTL underlying the phenotype supplied in traits.

maxIter maximum number of iterations. Only used when number of traits is greater than 1.

Va marker effect variance for additive effects. If value is NULL, a reasonable starting point is chosen automatically.

Vd marker effect variance for dominance effects. If value is NULL, a reasonable starting point is chosen automatically.

Ve error variance. If value is NULL, a reasonable starting point is chosen automatically.

useEM use EM to solve variance components. If false, the initial values are considered true.

tol tolerance for EM algorithm convergence

useReps should population’s reps slot be used to model heterogeneous error variance

simParam an object of SimParam

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=20)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)
SP$addSnpChip(10)

#Create population
pop = newPop(founderPop, simParam=SP)

#Run GS model and set EBV
ans = RRBLUP_D2(pop, simParam=SP)
pop = setEBV(pop, ans, simParam=SP)

#Evaluate accuracy
cor(gv(pop), ebv(pop))
**Description**

Fits an RR-BLUP model that estimates separate marker effects for females and males. Useful for predicting GCA of parents in single cross hybrids. Can also predict performance of specific single cross hybrids.

**Usage**

```r
RRBLUP_GCA(
  pop,
  traits = 1,
  use = "pheno",
  snpChip = 1,
  useQtl = FALSE,
  maxIter = 40L,
  useReps = FALSE,
  simParam = NULL,
  ...
)
```

**Arguments**

- **pop**
  - a **Pop-class** to serve as the training population

- **traits**
  - an integer indicating the trait to model, or a function of the traits returning a single value.

- **use**
  - train model using phenotypes "pheno", genetic values "gv", estimated breeding values "ebv", breeding values "bv", or randomly "rand"

- **snpChip**
  - an integer indicating which SNP chip genotype to use

- **useQtl**
  - should QTL genotypes be used instead of a SNP chip. If TRUE, snpChip specifies which trait's QTL to use, and thus these QTL may not match the QTL underlying the phenotype supplied in traits.

- **maxIter**
  - maximum number of iterations for convergence.

- **useReps**
  - should population's reps slot be used to model heterogeneous error variance

- **simParam**
  - an object of **SimParam**

- **...**
  - additional arguments if using a function for traits

**Examples**

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=20)

#Set simulation parameters
```
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)
SP$addSnpChip(10)

#Create population
pop = newPop(founderPop, simParam=SP)

#Run GS model and set EBV
ans = RRBLUP_GCA(pop, simParam=SP)
pop = setEBV(pop, ans, simParam=SP)

#Evaluate accuracy
cor(gv(pop), ebv(pop))

---

**RRBLUP_GCA2**

**RR-BLUP GCA Model 2**

**Description**

Fits an RR-BLUP model that estimates separate marker effects for females and males. This implementation is meant for situations where **RRBLUP_GCA** is too slow. Note that RRBLUP_GCA2 is only faster in certain situations. Most users should use **RRBLUP_GCA**.

**Usage**

```r
RRBLUP_GCA2(
  pop,
  traits = 1,
  use = "pheno",
  snpChip = 1,
  useQtl = FALSE,
  maxIter = 10,
  VuF = NULL,
  VuM = NULL,
  Ve = NULL,
  useEM = TRUE,
  tol = 1e-06,
  useReps = FALSE,
  simParam = NULL,
  ...
)
```

**Arguments**

- **pop**
  - a **Pop-class** to serve as the training population
- **traits**
  - an integer indicating the trait to model, or a function of the traits returning a single value.
use train model using phenotypes "pheno", genetic values "gv", estimated breeding values "ebv", breeding values "bv", or randomly "rand"

snpChip an integer indicating which SNP chip genotype to use

useQtl should QTL genotypes be used instead of a SNP chip. If TRUE, snpChip specifies which trait's QTL to use, and thus these QTL may not match the QTL underlying the phenotype supplied in traits.

maxIter maximum number of iterations for convergence.

VuF marker effect variance for females. If value is NULL, a reasonable starting point is chosen automatically.

VuM marker effect variance for males. If value is NULL, a reasonable starting point is chosen automatically.

Ve error variance. If value is NULL, a reasonable starting point is chosen automatically.

useEM use EM to solve variance components. If false, the initial values are considered true.

tol tolerance for EM algorithm convergence

useReps should population’s reps slot be used to model heterogeneous error variance

simParam an object of SimParam

... additional arguments if using a function for traits

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=20)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)
SP$addSnpChip(10)

#Create population
pop = newPop(founderPop, simParam=SP)

#Run GS model and set EBV
ans = RRBLUP_GCA2(pop, simParam=SP)
pop = setEBV(pop, ans, simParam=SP)

#Evaluate accuracy
cor(gv(pop), ebv(pop))
RRBLUP_SCA

RR-BLUP SCA Model

Description

An extension of RRBLUP_GCA that adds dominance effects. Note that we have not seen any consistent benefit of this model over RRBLUP_GCA.

Usage

RRBLUP_SCA(
    pop,
    traits = 1,
    use = "pheno",
    snpChip = 1,
    useQtl = FALSE,
    maxIter = 40L,
    useReps = FALSE,
    simParam = NULL,
    ...
)

Arguments

- **pop** - a Pop-class to serve as the training population
- **traits** - an integer indicating the trait to model, or a function of the traits returning a single value.
- **use** - train model using phenotypes "pheno", genetic values "gv", estimated breeding values "ebv", breeding values "bv", or randomly "rand"
- **snpChip** - an integer indicating which SNP chip genotype to use
- **useQtl** - should QTL genotypes be used instead of a SNP chip. If TRUE, snpChip specifies which trait’s QTL to use, and thus these QTL may not match the QTL underlying the phenotype supplied in traits.
- **maxIter** - maximum number of iterations for convergence.
- **useReps** - should population’s reps slot be used to model heterogeneous error variance
- **simParam** - an object of SimParam
- **...** - additional arguments if using a function for traits

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=20)

#Set simulation parameters
SP = SimParam$new(founderPop)
# Example usage

```r
SP$addTraitA(10)
SP$setVarE(h2=0.5)
SP$addSnpChip(10)

# Create population
pop = newPop(founderPop, simParam=SP)

# Run GS model and set EBV
ans = RRBLUP_SCA(pop, simParam=SP)
pop = setEBV(pop, ans, simParam=SP)

# Evaluate accuracy
cor(gv(pop), ebv(pop))
```

---

## RRBLUP_SCA2

**RR-BLUP SCA Model 2**

### Description

Fits an RR-BLUP model that estimates separate additive effects for females and males and a dominance effect. This implementation is meant for situations where `RRBLUP_SCA` is too slow. Note that `RRBLUP_SCA2` is only faster in certain situations. Most users should use `RRBLUP_SCA`.

### Usage

```r
RRBLUP_SCA2(
    pop,
    traits = 1,
    use = "pheno",
    snpChip = 1,
    useQtl = FALSE,
    maxIter = 10,
    VuF = NULL,
    VuM = NULL,
    VuD = NULL,
    Ve = NULL,
    useEM = TRUE,
    tol = 1e-06,
    useReps = FALSE,
    simParam = NULL,
    ...
)
```

### Arguments

- `pop`  
  A `Pop-class` to serve as the training population
traits an integer indicating the trait to model, or a function of the traits returning a single value.

use train model using phenotypes "pheno", genetic values "gv", estimated breeding values "ebv", breeding values "bv", or randomly "rand"

snpChip an integer indicating which SNP chip genotype to use

useQtl should QTL genotypes be used instead of a SNP chip. If TRUE, snpChip specifies which trait's QTL to use, and thus these QTL may not match the QTL underlying the phenotype supplied in traits.

maxIter maximum number of iterations for convergence.

VuF marker effect variance for females. If value is NULL, a reasonable starting point is chosen automatically.

VuM marker effect variance for males. If value is NULL, a reasonable starting point is chosen automatically.

VuD marker effect variance for dominance. If value is NULL, a reasonable starting point is chosen automatically.

Ve error variance. If value is NULL, a reasonable starting point is chosen automatically.

useEM use EM to solve variance components. If false, the initial values are considered true.

tol tolerance for EM algorithm convergence

useReps should population's reps slot be used to model heterogeneous error variance

simParam an object of SimParam

... additional arguments if using a function for traits

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=20)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)
SP$addSnpChip(10)

#Create population
pop = newPop(founderPop, simParam=SP)

#Run GS model and set EBV
ans = RRBLUP_SCA2(pop, simParam=SP)
pop = setEBV(pop, ans, simParam=SP)

#Evaluate accuracy
cor(gv(pop), ebv(pop))
RRsol-class  \textit{RR-BLUP Solution}\footnote{\texttt{RR-BLUP}}

\textbf{Description}  
Contains output from AlphaSimR’s genomic selection functions.

\textbf{Slots}  
gv Trait(s) for estimating genetic values  
bv Trait(s) for estimating breeding values  
female Trait(s) for estimating GCA in the female pool  
male Trait(s) for estimating GCA in the male pool  
Vu Estimated marker variance(s)  
Ve Estimated error variance

\begin{verbatim}
runMacs  \textit{Create founder haplotypes using MaCS}\footnote{\texttt{runMacs}}
\end{verbatim}

\textbf{Description}  
Uses the MaCS software to produce founder haplotypes.

\textbf{Usage}  
\begin{verbatim}
runMacs(  
nInd,  
nChr = 1,  
segSites = NULL,  
inbred = FALSE,  
species = "GENERIC",  
split = NULL,  
ploidy = 2L,  
manualCommand = NULL,  
manualGenLen = NULL,  
nThreads = NULL)
\end{verbatim}
Arguments

- **nInd**: number of individuals to simulate
- **nChr**: number of chromosomes to simulate
- **segSites**: number of segregating sites to keep per chromosome. A value of NULL results in all sites being retained.
- **inbred**: should founder individuals be inbred
- **species**: species history to simulate. See details.
- **split**: an optional historic population split in terms of generations ago.
- **ploidy**: ploidy level of organism
- **manualCommand**: user provided MaCS options. For advanced users only.
- **manualGenLen**: user provided genetic length. This must be supplied if using manualCommand. If not using manualCommand, this value will replace the predefined genetic length for the species. However, this the genetic length is only used by AlphaSimR and is not passed to MaCS, so MaCS still uses the predefined genetic length. For advanced users only.
- **nThreads**: if OpenMP is available, this will allow for simulating chromosomes in parallel. If the value is NULL, the number of threads is automatically detected.

Details

The current species histories are included: GENERIC, CATTLE, WHEAT, MAIZE, and EURO-PEAN.

Value

an object of **MapPop-class**

Examples

```r
# Creates a populations of 10 outbred individuals
# Their genome consists of 1 chromosome and 100 segregating sites
founderPop = runMacs(nInd=10,nChr=1,segSites=100)
```

Description

A wrapper function for **runMacs**. This wrapper is designed to be easier to use than supply custom commands to manualCommand in **runMacs**. It effectively automates the creation of an appropriate manualCommand using user supplied variables, but only deals with a subset of the possibilities. The defaults were chosen to match species="GENERIC" in **runMacs**.
Usage

runMacs2(
  nInd,  # number of individuals to simulate
  nChr = 1,  # number of chromosomes to simulate
  segSites = NULL,  # number of segregating sites to keep per chromosome
  Ne = 100,  # effective population size
  bp = 1e+08,  # base pair length of chromosome
  genLen = 1,  # genetic length of chromosome in Morgans
  mutRate = 2.5e-08,  # per base pair mutation rate
  histNe = c(500, 1500, 6000, 12000, 1e+05),  # effective population size in previous generations
  histGen = c(100, 1000, 10000, 1e+05, 1e+06),  # number of generations ago for effective population sizes given in histNe
  inbred = FALSE,  # should founder individuals be inbred
  split = NULL,  # an optional historic population split in terms of generations ago
  ploidy = 2L,  # ploidy level of organism
  returnCommand = FALSE,  # should the command passed to manualCommand in runMacs be returned. If TRUE, MaCS will not be called and the command is returned instead.
  nThreads = NULL  # if OpenMP is available, this will allow for simulating chromosomes in parallel. If the value is NULL, the number of threads is automatically detected.
)

Arguments

- **nInd**: number of individuals to simulate
- **nChr**: number of chromosomes to simulate
- **segSites**: number of segregating sites to keep per chromosome
- **Ne**: effective population size
- **bp**: base pair length of chromosome
- **genLen**: genetic length of chromosome in Morgans
- **mutRate**: per base pair mutation rate
- **histNe**: effective population size in previous generations
- **histGen**: number of generations ago for effective population sizes given in histNe
- **inbred**: should founder individuals be inbred
- **split**: an optional historic population split in terms of generations ago
- **ploidy**: ploidy level of organism
- **returnCommand**: should the command passed to manualCommand in runMacs be returned. If TRUE, MaCS will not be called and the command is returned instead.
- **nThreads**: if OpenMP is available, this will allow for simulating chromosomes in parallel. If the value is NULL, the number of threads is automatically detected.

Value

an object of MapPop-class or if returnCommand is true a string giving the MaCS command passed to the manualCommand argument of runMacs.
Examples

# Creates a populations of 10 outbred individuals
# Their genome consists of 1 chromosome and 100 segregating sites
# The command is equivalent to using species="GENERIC" in runMacs
founderPop = runMacs2(nInd=10,nChr=1,segSites=100)

sampleHaplo Sample haplotypes from a MapPop

Description

Creates a new MapPop-class from an existing MapPop-class by randomly sampling haplotypes.

Usage

sampleHaplo(mapPop, nInd, inbred = FALSE, ploidy = NULL, replace = TRUE)

Arguments

mapPop the MapPop-class used to sample haplotypes
nInd the number of individuals to create
inbred should new individuals be fully inbred
ploidy new ploidy level for organism. If NULL, the ploidy level of the mapPop is used.
replace should haplotypes be sampled with replacement

Value

an object of MapPop-class

Examples

founderPop = quickHaplo(nInd=2,nChr=2,segSites=11,inbred=TRUE)
founderPop = sampleHaplo(mapPop=founderPop,nInd=20)
selectCross  

**Select and randomly cross**

**Description**

This is a wrapper that combines the functionalities of `randCross` and `selectInd`. The purpose of this wrapper is to combine both selection and crossing in one function call that minimized the amount of intermediate populations created. This reduces RAM usage and simplifies code writing. Note that this wrapper does not provide the full functionality of either function.

**Usage**

```r
selectCross(
  pop,
  nInd = NULL,
  nFemale = NULL,
  nMale = NULL,
  nCrosses,
  nProgeny = 1,
  trait = 1,
  use = "pheno",
  selectTop = TRUE,
  simParam = NULL,
  ..., 
  balance = TRUE
)
```

**Arguments**

- `pop` an object of `Pop-class`
- `nInd` the number of individuals to select. These individuals are selected without regards to sex and it supercedes values for nFemale and nMale. Thus if the simulation uses sexes, it is likely better to leave this value as NULL and use nFemale and nMale instead.
- `nFemale` the number of females to select. This value is ignored if nInd is set.
- `nMale` the number of males to select. This value is ignored if nInd is set.
- `nCrosses` total number of crosses to make
- `nProgeny` number of progeny per cross
- `trait` the trait for selection. Either a number indicating a single trait or a function returning a vector of length nInd.
- `use` select on genetic values "gv", estimated breeding values "ebv", breeding values "bv", phenotypes "pheno", or randomly "rand"
- `selectTop` selects highest values if true. Selects lowest values if false.
- `simParam` an object of `SimParam`
selectFam

... additional arguments if using a function for trait balance
if using sexes, this option will balance the number of progeny per parent. This argument occurs after ..., so the argument name must be matched exactly.

Value

Returns an object of Pop-class

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)

#Select 4 individuals and make 8 crosses
pop2 = selectCross(pop, nInd=4, nCrosses=8, simParam=SP)
Arguments

- **pop**: and object of `Pop-class`, `HybridPop-class` or `MegaPop-class`
- **nFam**: the number of families to select
- **trait**: the trait for selection. Either a number indicating a single trait or a function returning a vector of length nInd.
- **use**: select on genetic values "gv", estimated breeding values "ebv", breeding values "bv", phenotypes "pheno", or randomly "rand"
- **sex**: which sex to select. Use "B" for both, "F" for females and "M" for males. If the simulation is not using sexes, the argument is ignored.
- **famType**: which type of family to select. Use "B" for full-sib families, "F" for half-sib families on female side and "M" for half-sib families on the male side.
- **selectTop**: selects highest values if true. Selects lowest values if false.
- **returnPop**: should results be returned as a `Pop-class`. If FALSE, only the index of selected individuals is returned.
- **candidates**: an optional vector of eligible selection candidates.
- **simParam**: an object of `SimParam`
- **...**: additional arguments if using a function for trait

Value

Returns an object of `Pop-class`, `HybridPop-class` or `MegaPop-class`

Examples

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)

#Create 3 biparental families with 10 progeny
pop2 = randCross(pop, nCrosses=3, nProgeny=10, simParam=SP)

#Select best 2 families
pop3 = selectFam(pop2, 2, simParam=SP)
```
**selectInd**

*Select individuals*

**Description**

Selects a subset of nInd individuals from a population.

**Usage**

```r
selectInd(
  pop,
  nInd,
  trait = 1,
  use = "pheno",
  sex = "B",
  selectTop = TRUE,
  returnPop = TRUE,
  candidates = NULL,
  simParam = NULL,
  ...
)
```

**Arguments**

- **pop**: and object of **Pop-class**, **HybridPop-class** or **MegaPop-class**
- **nInd**: the number of individuals to select
- **trait**: the trait for selection. Either a number indicating a single trait or a function returning a vector of length nInd.
- **use**: select on genetic values "gv", estimated breeding values "ebv", breeding values "bv", phenotypes "pheno", or randomly "rand"
- **sex**: which sex to select. Use "B" for both, "F" for females and "M" for males. If the simulation is not using sexes, the argument is ignored.
- **selectTop**: selects highest values if true. Selects lowest values if false.
- **returnPop**: should results be returned as a **Pop-class**. If FALSE, only the index of selected individuals is returned.
- **candidates**: an optional vector of eligible selection candidates.
- **simParam**: an object of **SimParam**
- **...**: additional arguments if using a function for trait

**Value**

Returns an object of **Pop-class**, **HybridPop-class** or **MegaPop-class**
selectOP

Select open pollinating plants

Description

This function models selection in an open pollinating plant population. It allows for varying the percentage of selfing. The function also provides an option for modeling selection as occurring before or after pollination.

Usage

```r
selectOP(
  pop,
  nInd,  # the number of plants to select
  nSeeds,  # number of seeds per plant
  probSelf = 0,  # percentage of seeds expected from selfing. Value ranges from 0 to 1.
  pollenControl = FALSE,  # before or after pollination.
  trait = 1,
  use = "pheno",
  selectTop = TRUE,
  candidates = NULL,
  simParam = NULL,
  ...
)
```

Arguments

- `pop` and object of `Pop-class` or `MegaPop-class`
- `nInd` the number of plants to select
- `nSeeds` number of seeds per plant
- `probSelf` percentage of seeds expected from selfing. Value ranges from 0 to 1.

Examples

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)

#Select best 5
pop2 = selectInd(pop, 5, simParam=SP)
```
pollenControl are plants selected before pollination

trait the trait for selection. Either a number indicating a single trait or a function returning a vector of length nInd.

use select on genetic values "gv", estimated breeding values "ebv", breeding values "bv", phenotypes "pheno", or randomly "rand"

selectTop selects highest values if true. Selects lowest values if false.

candidates an optional vector of eligible selection candidates.

simParam an object of SimParam

... additional arguments if using a function for trait

Value

Returns an object of Pop-class or MegaPop-class

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)

#Create new population by selecting the best 3 plant
#Assuming 50% selfing in plants and 10 seeds per plant
pop2 = selectOP(pop, nInd=3, nSeeds=10, probSelf=0.5, simParam=SP)
selectWithinFam

sex = "B",
famType = "B",
selectTop = TRUE,
returnPop = TRUE,
candidates = NULL,
simParam = NULL,
...
)

Arguments

pop and object of Pop-class, HybridPop-class or MegaPop-class
nInd the number of individuals to select within a family
trait the trait for selection. Either a number indicating a single trait or a function returning a vector of length nInd.
use select on genetic values "gv", estimated breeding values "ebv", breeding values "bv", phenotypes "pheno", or randomly "rand"
sex which sex to select. Use "B" for both, "F" for females and "M" for males. If the simulation is not using sexes, the argument is ignored.
famType which type of family to select. Use "B" for full-sib families, "F" for half-sib families on female side and "M" for half-sib families on the male side.
selectTop selects highest values if true. Selects lowest values if false.
returnPop should results be returned as a Pop-class. If FALSE, only the index of selected individuals is returned.
candidates an optional vector of eligible selection candidates.
simParam an object of SimParam
... additional arguments if using a function for trait

Value

Returns an object of Pop-class, HybridPop-class or MegaPop-class

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)

#Create population
pop = newPop(founderPop, simParam=SP)

#Create 3 biparental families with 10 progeny
pop2 = randCross(pop, nCrosses=3, nProgeny=10, simParam=SP)
# Select best individual per family
pop3 = selectWithinFam(pop2, 1, simParam=SP)

---

## Self

### Self individuals

**Description**

Creates selfed progeny from each individual in a population. Only works when sexes is "no".

**Usage**

`self(pop, nProgeny = 1, parents = NULL, keepParents = TRUE, simParam = NULL)`

**Arguments**

- `pop`: an object of `Pop-class`
- `nProgeny`: total number of selfed progeny per individual
- `parents`: an optional vector of indices for allowable parents
- `keepParents`: should previous parents be used for mother and father.
- `simParam`: an object of `SimParam`

**Value**

Returns an object of `Pop-class`

**Examples**

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)

# Create population
pop = newPop(founderPop, simParam=SP)

# Self pollinate each individual
pop2 = self(pop, simParam=SP)
```
selIndex  

Selection index

Description
Calculates values of a selection index given trait values and weights. This function is intended to be used in combination with selection functions working on populations such as selectInd.

Usage
selIndex(Y, b, scale = FALSE)

Arguments
- Y: a matrix of trait values
- b: a vector of weights
- scale: should Y be scaled and centered

Examples
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
#Model two genetically correlated traits
G = 1.5*diag(2)-0.5 #Genetic correlation matrix
SP$addTraitA(10, mean=c(0,0), var=c(1,1), corA=G)
SP$setVarE(h2=c(0.5,0.5))

#Create population
pop = newPop(founderPop, simParam=SP)

#Calculate Smith-Hazel weights
econWt = c(1, 1)
b = smithHazel(econWt, varG(pop), varP(pop))

#Selection 2 best individuals using Smith-Hazel index
#selIndex is used as a trait
pop2 = selectInd(pop, nInd=2, trait=selIndex, simParam=SP, b=b)
**selInt**

*Selection intensity*

**Description**

Calculates the standardized selection intensity

**Usage**

```
selInt(p)
```

**Arguments**

- `p` the proportion of individuals selected

**Examples**

```
selInt(0.1)
```

---

**setEBV**

*Set EBV*

**Description**

Adds genomic estimated values to a population's EBV slot using output from a genomic selection functions. The genomic estimated values can be either estimated breeding values, estimated genetic values, or estimated general combining values.

**Usage**

```
setEBV(
    pop, solution, value = "gv", targetPop = NULL, append = FALSE, simParam = NULL
)
```
**Arguments**

- **pop** an object of **Pop-class**
- **solution** an object of **RRsol-class**
- **value** the genomic value to be estimated. Can be either "gv", "bv", "female", or "male".
- **targetPop** an optional target population that can be used when value is "bv", "female", or "male". When supplied, the allele frequency in the targetPop is used to set these values.
- **append** should estimated values be appended to existing data in the EBV slot. If TRUE, a new column is added. If FALSE, existing data is replaced with the new estimates.
- **simParam** an object of **SimParam**

**Value**

Returns an object of **Pop-class**

**Examples**

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=20)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)
SP$addSnpChip(10)

#Create population
pop = newPop(founderPop, simParam=SP)

#Run GS model and set EBV
ans = RRBLUP(pop, simParam=SP)
pop = setEBV(pop, ans, simParam=SP)

#Evaluate accuracy
cor(gv(pop), ebv(pop))
```

---

**setPheno**

Set phenotypes

**Description**

Sets phenotypes for all traits by adding random error from a multivariate normal distribution.
**setPheno**

**Usage**

```r
definePhenos(
    pop,
    h2 = NULL,
    H2 = NULL,
    varE = NULL,
    reps = 1,
    fixEff = 1L,
    p = NULL,
    onlyPheno = FALSE,
    simParam = NULL
)
```

**Arguments**

- `pop`: an object of **Pop-class** or **HybridPop-class**
- `h2`: a vector of desired narrow-sense heritabilities for each trait. See details.
- `H2`: a vector of desired broad-sense heritabilities for each trait. See details.
- `varE`: error (co)variances for traits. See details.
- `reps`: number of replications for phenotype. See details.
- `fixEff`: fixed effect to assign to the population. Used by genomic selection models only.
- `p`: the p-value for the environmental covariate used by GxE traits. If NULL, a value is sampled at random.
- `onlyPheno`: should only the phenotype be returned, see return
- `simParam`: an object of **SimParam**

**Details**

There are three arguments for setting the error variance of a phenotype: `h2`, `H2`, and `varE`. The user should only use one of these arguments. If the user supplies values for more than one, only one will be used according to order in which they are listed above.

The `h2` argument allows the user to specify the error variance according to narrow-sense heritability. This calculation uses the additive genetic variance and total genetic variance in the founder population. Thus, the heritability relates to the founder population and not the current population.

The `H2` argument allows the user to specify the error variance according to broad-sense heritability. This calculation uses the total genetic variance in the founder population. Thus, the heritability relates to the founder population and not the current population.

The `varE` argument allows the user to specify the error variance directly. The user may supply a vector describing the error variance for each trait or supply a matrix that specify the covariance of the errors.

The `reps` parameter is for convenient representation of replicated data. It is intended to represent replicated yield trials in plant breeding programs. In this case, `varE` is set to the plot error and `reps` is set to the number of plots per entry. The resulting phenotype represents the entry-means.
setPhenoGCA

Value

Returns an object of Pop-class or HybridPop-class if onlyPheno=FALSE, if onlyPheno=TRUE a matrix is returned.

Examples

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

#Create population
pop = newPop(founderPop, simParam=SP)

#Add phenotype with error variance of 1
pop = setPheno(pop, varE=1)

setPhenoGCA

Set GCA as phenotype

Description

Calculates general combining ability from a set of testers and returns these values as phenotypes for a population.

Usage

setPhenoGCA(
  pop,
  testers,
  use = "pheno",
  varE = NULL,
  reps = 1,
  fixEff = 1L,
  p = NULL,
  inbred = FALSE,
  onlyPheno = FALSE,
  simParam = NULL
)

Arguments

pop an object of Pop-class

testers an object of Pop-class
setPhenoProgTest

use true genetic value (gv) or phenotypes (pheno, default)
varE error variances for phenotype if use="pheno". A vector of length nTraits for independent error or a square matrix of dimensions nTraits for correlated errors.
reps number of replications for phenotype. See details.
fixEff fixed effect to assign to the population. Used by genomic selection models only.
p the p-value for the environmental covariate used by GxE traits. If NULL, a value is sampled at random.
inbred are both pop and testers fully inbred. They are only fully inbred if created by newPop using inbred founders or by the makeDH function
onlyPheno should only the phenotype be returned, see return
simParam an object of SimParam

Details
The reps parameter is for convenient representation of replicated data. It was intended for representation of replicated yield trials in plant breeding programs. In this case, varE is set to the plot error and reps is set to the number plots per entry. The resulting phenotype would reflect the mean of all replications.

Value
Returns an object of Pop-class or a matrix if onlyPheno=TRUE

Examples
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10, inbred=TRUE)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

#Create population
pop = newPop(founderPop, simParam=SP)

#Set phenotype to average per
pop2 = setPhenoGCA(pop, pop, use="gv", inbred=TRUE, simParam=SP)

setPhenoProgTest Set progeny test as phenotype

Description
Models a progeny test of individuals in 'pop'. Returns 'pop' with a phenotype representing the average performance of their progeny. The phenotype is generated by mating individuals in 'pop' to randomly chosen individuals in testPop a number of times equal to 'nMatePerInd'.

Usage

setPhenoProgTest(
    pop,  
    testPop,  
    nMatePerInd = 1L,  
    use = "pheno",  
    varE = NULL,  
    reps = 1,  
    fixEff = 1L,  
    p = NULL,  
    onlyPheno = FALSE,  
    simParam = NULL
)

Arguments

- **pop**: an object of `Pop-class`
- **testPop**: an object of `Pop-class`
- **nMatePerInd**: number of times an individual in `pop` is mated to an individual in `testPop`
- **use**: true genetic value (`gv`) or phenotypes (`pheno`, default)
- **varE**: error variances for phenotype if `use="pheno"`. A vector of length `nTraits` for independent error or a square matrix of dimensions `nTraits` for correlated errors.
- **reps**: number of replications for phenotype. See details.
- **fixEff**: fixed effect to assign to the population. Used by genomic selection models only.
- **p**: the p-value for the environmental covariate used by GxE traits. If NULL, a value is sampled at random.
- **onlyPheno**: should only the phenotype be returned, see return
- **simParam**: an object of `SimParam`

Details

The `reps` parameter is for convenient representation of replicated data. It was intended for representation of replicated yield trials in plant breeding programs. In this case, `varE` is set to the plot error and `reps` is set to the number plots per entry. The resulting phenotype would reflect the mean of all replications.

Value

Returns an object of `Pop-class` or a matrix if `onlyPheno=TRUE`

Examples

```r
#Create founder haplotypes
defounderPop = quickHaplo(nInd=10, nChr=1, segSites=10, inbred=TRUE)

#Set simulation parameters
```
SimParam

SP = SimParam$new(founderPop)
SP$addTraitA(10)

# Create two populations of 5 individuals
pop1 = newPop(founderPop[1:5], simParam=SP)
pop2 = newPop(founderPop[6:10], simParam=SP)

# Set phenotype according to a progeny test
pop3 = setPhenoProgTest(pop1, pop2, use="gv", simParam=SP)

---

SimParam  Simulation parameters

Description

Container for global simulation parameters. Saving this object as SP will allow it to be accessed by function defaults.

Public fields

nThreads number of threads used on platforms with OpenMP support
snpChips list of SNP chips
invalidQt1 list of segregating sites that aren’t valid QTL
invalidSnp list of segregating sites that aren’t valid SNP
founderPop founder population used for variance scaling
finalizePop function applied to newly created populations. Currently does nothing and should only be changed by expert users.
allowEmptyPop if true, population arguments with nInd=0 will return an empty population without a warning instead of an error.
v the crossover interference parameter for a gamma model of recombination. A value of 1 indicates no crossover interference (e.g. Haldane mapping function). A value of 2.6 approximates the degree of crossover interference implied by the Kosambi mapping function. (default is 2.6)
p the proportion of crossovers coming from a non-interfering pathway. (default is 0)
quadProb the probability of quadrivalent pairing in an autopolyplloid. (default is 0)

Active bindings

traits list of traits
nChr number of chromosomes
nTraits number of traits
nSnpChips number of SNP chips
segSites segregating sites per chromosome
sexes sexes used for mating
sepMap are there separate genetic maps for males and females
genMap "matrix" of chromosome genetic maps
femaleMap "matrix" of chromosome genetic maps for females
maleMap "matrix" of chromosome genetic maps for males
centromere position of centromeres genetic map
femaleCentromere position of centromeres on female genetic map
maleCentromere position of centromeres on male genetic map
lastId last ID number assigned
isTrackPed is pedigree being tracked
pedigree pedigree matrix for all individuals
isTrackRec is recombination being tracked
recHist list of historic recombination events
haplotypes list of computed IBD haplotypes
varA additive genetic variance in founderPop
varG total genetic variance in founderPop
varE default error variance
version the version of AlphaSimR used to generate this object

Methods

Public methods:

- SimParam$new()
- SimParam$setTrackPed()
- SimParam$setTrackRec()
- SimParam$resetPed()
- SimParam$restrSegSites()
- SimParam$setSexes()
- SimParam$addSnpChip()
- SimParam$addStructuredSnpChip()
- SimParam$addTraitA()
- SimParam$addTraitAD()
- SimParam$addTraitAG()
- SimParam$addTraitADG()
- SimParam$addTraitAE()
- SimParam$addTraitADE()
- SimParam$addTraitAEG()
- SimParam$addTraitADEG()
- SimParam$manAddTrait()
- SimParam$switchTrait()
- SimParam$removeTrait()
- SimParam$setVarE()
• SimParam$setCorE()
• SimParam$rescaleTraits()
• SimParam$setRecombRatio()
• SimParam$switchGenMap()
• SimParam$switchFemaleMap()
• SimParam$switchMaleMap()
• SimParam$addToRec()
• SimParam$ibdHaplo()
• SimParam$updateLastId()
• SimParam$addToPed()
• SimParam$clone()

**Method new()**: Starts the process of building a new simulation by creating a new SimParam object and assigning a founder population to the class. It is recommended that you save the object with the name "SP", because subsequent functions will check your global environment for an object of this name if their simParam arguments are NULL. This allows you to call these functions without explicitly supplying a simParam argument with every call.

*Usage:*

```r
SimParam$new(founderPop)
```

*Arguments:*

founderPop an object of MapPop-class

*Examples:*

```
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
```

**Method setTrackPed()**: Sets pedigree tracking for the simulation. By default pedigree tracking is turned off. When turned on, the pedigree of all individuals created will be tracked, except those created by hybridCross. Turning off pedigree tracking will turn off recombination tracking if it is turned on.

*Usage:*

```r
SimParam$setTrackPed(isTrackPed, force = FALSE)
```

*Arguments:*

isTrackPed should pedigree tracking be on.
force should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing.

*Examples:*

```
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$setTrackPed(TRUE)
```
**Method** setTrackRec(): Sets recombination tracking for the simulation. By default recombination tracking is turned off. When turned on recombination tracking will also turn on pedigree tracking. Recombination tracking keeps records of all individuals created, except those created by `hybridCross`, because their pedigree is not tracked.

*Usage:*

```r
SimParam$setTrackRec(isTrackRec, force = FALSE)
```

*Arguments:*

- `isTrackRec`: should recombination tracking be on.
- `force`: should the check for a running simulation be ignored. Only set to `TRUE` if you know what you are doing.

*Examples:*

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$setTrackRec(TRUE)
```

**Method** resetPed(): Resets the internal lastId, the pedigree and recombination tracking (if in use) to the supplied lastId. Be careful using this function because it may introduce a bug if you use individuals from the deleted portion of the pedigree.

*Usage:*

```r
SimParam$resetPed(lastId = 0L)
```

*Arguments:*

- `lastId`: last ID to include in pedigree

*Examples:*

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)

#Create population
pop = newPop(founderPop, simParam=SP)
pop@id # 1:10

#Create another population after resetting pedigree
SP$resetPed()
pop2 = newPop(founderPop, simParam=SP)
pop2@id # 1:10
```

**Method** restrSegSites(): Sets restrictions on which segregating sites can serve as SNP and/or QTL.

*Usage:*

```r
```
SimParam$restrSegSites(
    minQtlPerChr = NULL,
    minSnpPerChr = NULL,
    overlap = FALSE,
    minSnpFreq = NULL
)

Arguments:
minQtlPerChr  the minimum number of segSites for QTLs. Can be a single value or a vector values for each chromosome.
minSnpPerChr  the minimum number of segSites for SNPs. Can be a single value or a vector values for each chromosome.
overlap      should SNP and QTL sites be allowed to overlap.
minSnpFreq   minimum allowable frequency for SNP loci. No minimum SNP frequency is used if value is NULL.

Examples:
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$restrSegSites(minQtlPerChr=5, minSnpPerChr=5)

Method setSexes(): Changes how sexes are determined in the simulation. The default sexes is "no", indicating all individuals are hermaphrodites. To add sexes to the simulation, run this function with "yes_sys" or "yes_rand". The value "yes_sys" will systematically assign sexes to newly created individuals as first male and then female. Populations with an odd number of individuals will have one more male than female. The value "yes_rand" will randomly assign a sex to each individual.

Usage:
SimParam$setSexes(sexes, force = FALSE)

Arguments:
sexes  acceptable value are "no", "yes_sys", or "yes_rand"
force  should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing.

Examples:
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$setSexes("yes_sys")

Method addSnpChip(): Randomly assigns eligible SNPs to a SNP chip

Usage:
SimParam$addSnpChip(nSnpPerChr, minSnpFreq = NULL, refPop = NULL)
Arguments:
nSnpPerChr number of SNPs per chromosome. Can be a single value or nChr values.
minSnpFreq minimum allowable frequency for SNP loci. If NULL, no minimum frequency is used.
refPop reference population for calculating SNP frequency. If NULL, the founder population is used.

Examples:
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addSnpChip(10)

Method addStructuredSnpChip(): Randomly selects the number of snps in structure and then assigns them to chips based on structure

Usage:
SimParam$addStructuredSnpChip(nSnpPerChr, structure, force = FALSE)

Arguments:
nSnpPerChr number of SNPs per chromosome. Can be a single value or nChr values.
structure a matrix. Rows are snp chips, columns are chips. If value is true then that snp is on that chip.
force should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing.

Method addTraitA(): Randomly assigns eligible QTLs for one or more additive traits. If simulating more than one trait, all traits will be pleiotrophic with correlated additive effects.

Usage:
SimParam$addTraitA(
  nQtlPerChr,
  mean = 0,
  var = 1,
  corA = NULL,
  gamma = FALSE,
  shape = 1,
  force = FALSE
)

Arguments:
 nQtlPerChr number of QTLs per chromosome. Can be a single value or nChr values.
 mean a vector of desired mean genetic values for one or more traits
 var a vector of desired genetic variances for one or more traits
 corA a matrix of correlations between additive effects
 gamma should a gamma distribution be used instead of normal
 shape the shape parameter for the gamma distribution
force should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing.

Examples:
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

**Method** `addTraitAD()`: Randomly assigns eligible QTLs for one or more traits with dominance. If simulating more than one trait, all traits will be pleiotrophic with correlated effects.

**Usage:**
```r
SimParam$addTraitAD(
  nQtlPerChr,
  mean = 0,
  var = 1,
  meanDD = 0,
  varDD = 0,
  corA = NULL,
  corDD = NULL,
  useVarA = TRUE,
  gamma = FALSE,
  shape = 1,
  force = FALSE
)
```

**Arguments:**
- `nQtlPerChr` number of QTLs per chromosome. Can be a single value or nChr values.
- `mean` a vector of desired mean genetic values for one or more traits
- `var` a vector of desired genetic variances for one or more traits
- `meanDD` mean dominance degree
- `varDD` variance of dominance degree
- `corA` a matrix of correlations between additive effects
- `corDD` a matrix of correlations between dominance degrees
- `useVarA` tune according to additive genetic variance if true. If FALSE, tuning is performed according to total genetic variance.
- `gamma` should a gamma distribution be used instead of normal
- `shape` the shape parameter for the gamma distribution
- `force` should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing.

Examples:
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)

**Method addTraitAG()**: Randomly assigns eligible QTLs for one or more additive GxE traits. If simulating more than one trait, all traits will be pleiotrophic with correlated effects.

**Usage**:

```r
SimParam$addTraitAG(
  nQtlPerChr,
  mean = 0,
  var = 1,
  varGxE = 1e-06,
  varEnv = 0,
  corA = NULL,
  corGxE = NULL,
  gamma = FALSE,
  shape = 1,
  force = FALSE
)
```

**Arguments**:

- `nQtlPerChr` number of QTLs per chromosome. Can be a single value or nChr values.
- `mean` a vector of desired mean genetic values for one or more traits
- `var` a vector of desired genetic variances for one or more traits
- `varGxE` a vector of total genotype-by-environment variances for the traits
- `varEnv` a vector of environmental variances for one or more traits
- `corA` a matrix of correlations between additive effects
- `corGxE` a matrix of correlations between GxE effects
- `gamma` should a gamma distribution be used instead of normal
- `shape` the shape parameter for the gamma distribution
- `force` should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing.

**Examples**:

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAG(10, varGxE=2)
```

**Method addTraitADG()**: Randomly assigns eligible QTLs for a trait with dominance and GxE.

**Usage**:

```r
SimParam$addTraitADG(
  nQtlPerChr,
  mean = 0,
  var = 1,
  varEnv = 1e-06,
)```
SimParam

\[
\begin{align*}
\text{varGxE} &= 1e-06, \\
\text{meanDD} &= 0, \\
\text{varDD} &= 0, \\
\text{corA} &= \text{NULL}, \\
\text{corDD} &= \text{NULL}, \\
\text{corGxE} &= \text{NULL}, \\
\text{useVarA} &= \text{TRUE}, \\
\text{gamma} &= \text{FALSE}, \\
\text{shape} &= 1, \\
\text{force} &= \text{FALSE}
\end{align*}
\]

Arguments:

- `nQtlPerChr` number of QTLs per chromosome. Can be a single value or nChr values.
- `mean` a vector of desired mean genetic values for one or more traits
- `var` a vector of desired genetic variances for one or more traits
- `varEnv` a vector of environmental variances for one or more traits
- `varGxE` a vector of total genotype-by-environment variances for the traits
- `meanDD` mean dominance degree
- `varDD` variance of dominance degree
- `corA` a matrix of correlations between additive effects
- `corDD` a matrix of correlations between dominance degrees
- `corGxE` a matrix of correlations between GxE effects
- `useVarA` tune according to additive genetic variance if true
- `gamma` should a gamma distribution be used instead of normal
- `shape` the shape parameter for the gamma distribution
- `force` should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing.

Examples:

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitADG(10, meanDD=0.5, varGxE=2)

Method `addTraitAE()`: Randomly assigns eligible QTLs for one or more additive and epistasis traits. If simulating more than one trait, all traits will be pleiotrophic with correlated additive effects.

Usage:

SimParam$addTraitAE(
    nQtlPerChr,
    mean = 0,
    var = 1,
    relAA = 0,
    corA = NULL,
corAA = NULL,
useVarA = TRUE,
gamma = FALSE,
shape = 1,
force = FALSE
)

Arguments:

nQtlPerChr number of QTLs per chromosome. Can be a single value or nChr values.
mean a vector of desired mean genetic values for one or more traits
var a vector of desired genetic variances for one or more traits
relAA the relative value of additive-by-additive variance compared to additive variance in a diploid organism with allele frequency 0.5
corA a matrix of correlations between additive effects
corAA a matrix of correlations between additive-by-additive effects
useVarA tune according to additive genetic variance if true. If FALSE, tuning is performed according to total genetic variance.
gamma should a gamma distribution be used instead of normal
shape the shape parameter for the gamma distribution
force should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing.

Examples:
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

Method addTraitADE(): Randomly assigns eligible QTLs for one or more traits with dominance and epistasis. If simulating more than one trait, all traits will be pleiotrophic with correlated effects.

Usage:
SimParam$addTraitADE(
  nQtlPerChr,
  mean = 0,
  var = 1,
  meanDD = 0,
  varDD = 0,
  relAA = 0,
  corA = NULL,
  corDD = NULL,
  corAA = NULL,
  useVarA = TRUE,
  gamma = FALSE,
  shape = 1,
  force = FALSE
)

Arguments:

nQtlPerChr number of QTLs per chromosome. Can be a single value or nChr values.
**mean**  a vector of desired mean genetic values for one or more traits
**var**  a vector of desired genetic variances for one or more traits
**meanDD**  mean dominance degree
**varDD**  variance of dominance degree
**relAA**  the relative value of additive-by-additive variance compared to additive variance in a diploid organism with allele frequency 0.5
**corA**  a matrix of correlations between additive effects
**corDD**  a matrix of correlations between dominance degrees
**corAA**  a matrix of correlations between additive-by-additive effects
**useVarA**  tune according to additive genetic variance if true. If FALSE, tuning is performed according to total genetic variance.
**gamma**  should a gamma distribution be used instead of normal
**shape**  the shape parameter for the gamma distribution
**force**  should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing.

**Examples:**

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAEG(10)
```

**Method**  `addTraitAEG()`: Randomly assigns eligible QTLs for one or more additive and epistasis GxE traits. If simulating more than one trait, all traits will be pleiotrophic with correlated effects.

**Usage:**

```r
SimParam$addTraitAEG(
  nQtlPerChr,  # number of QTLs per chromosome. Can be a single value or nChr values.
  mean = 0,    # a vector of desired mean genetic values for one or more traits
  var = 1,     # a vector of desired genetic variances for one or more traits
  relAA = 0,   # the relative value of additive-by-additive variance compared to additive variance in a diploid organism with allele frequency 0.5
  varGxE = 1e-06,  # correlation between additive and epistasis effects
  varEnv = 0,  # variance of environmental effect
  corA = NULL,  # correlation matrix for additive effects
  corAA = NULL, # correlation matrix for additive-by-additive effects
  useVarA = TRUE,  # tune according to additive genetic variance
  gamma = FALSE,  # should a gamma distribution be used instead of normal
  shape = 1,     # the shape parameter for the gamma distribution
  force = FALSE  # should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing.
)
```

**Arguments:**

nQtlPerChr  number of QTLs per chromosome. Can be a single value or nChr values.
mean  a vector of desired mean genetic values for one or more traits
var  a vector of desired genetic variances for one or more traits
relAA the relative value of additive-by-additive variance compared to additive variance in a diploid organism with allele frequency 0.5
varGxE a vector of total genotype-by-environment variances for the traits
varEnv a vector of environmental variances for one or more traits
corA a matrix of correlations between additive effects
corAA a matrix of correlations between additive-by-additive effects
corGxE a matrix of correlations between GxE effects
useVarA tune according to additive genetic variance if true. If FALSE, tuning is performed according to total genetic variance.
gamma should a gamma distribution be used instead of normal
shape the shape parameter for the gamma distribution
force should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing.

Examples:
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitADEG(10, varGxE=2)

Method addTraitADEG(): Randomly assigns eligible QTLs for a trait with dominance, epistasis and GxE.

Usage:
SimParam$addTraitADEG(
  nQtlPerChr,
  mean = 0,
  var = 1,
  varEnv = 1e-06,
  varGxE = 1e-06,
  meanDD = 0,
  varDD = 0,
  relAA = 0,
  corA = NULL,
  corDD = NULL,
  corAA = NULL,
  corGxE = NULL,
  useVarA = TRUE,
  gamma = FALSE,
  shape = 1,
  force = FALSE
)

Arguments:
nQtlPerChr number of QTLs per chromosome. Can be a single value or nChr values.
mean a vector of desired mean genetic values for one or more traits
var a vector of desired genetic variances for one or more traits
SimParam

varEnv a vector of environmental variances for one or more traits
varGxE a vector of total genotype-by-environment variances for the traits
meanDD mean dominance degree
varDD variance of dominance degree
relAA the relative value of additive-by-additive variance compared to additive variance in a
diploid organism with allele frequency 0.5
corA a matrix of correlations between additive effects
corDD a matrix of correlations between dominance degrees
corAA a matrix of correlations between additive-by-additive effects
corGxE a matrix of correlations between GxE effects
useVarA tune according to additive genetic variance if true
gamma should a gamma distribution be used instead of normal
shape the shape parameter for the gamma distribution
force should the check for a running simulation be ignored. Only set to TRUE if you know
what you are doing.

Examples:
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitADEG(10, meanDD=0.5, varGxE=2)

Method manAddTrait(): Manually add a new trait to the simulation.

Usage:
SimParam$manAddTrait(lociMap, varE = NA_real_, force = FALSE)

Arguments:
lociMap a new object descended from LociMap-class
varE default error variance for phenotype, optional
force should the check for a running simulation be ignored. Only set to TRUE if you know
what you are doing

Method switchTrait(): Switch a trait in the simulation.

Usage:
SimParam$switchTrait(traitPos, lociMap, varE = NA_real_, force = FALSE)

Arguments:
traitPos an integer indicate which trait to switch
lociMap a new object descended from LociMap-class
varE default error variance for phenotype, optional
force should the check for a running simulation be ignored. Only set to TRUE if you know
what you are doing

Method removeTrait(): Remove a trait from the simulation
**Usage:**
SimParam$removeTrait(traits, force = FALSE)

**Arguments:**
- **traits** an integer vector indicating which traits to remove
- **force** should the check for a running simulation be ignored. Only set to TRUE if you know what you are doing

**Method** setVarE(): Defines a default value for error variances in the simulation.

**Usage:**
SimParam$setVarE(h2 = NULL, H2 = NULL, varE = NULL)

**Arguments:**
- **h2** a vector of desired narrow-sense heritabilities
- **H2** a vector of desired broad-sense heritabilities
- **varE** a vector or matrix of error variances

**Examples:**

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)
```

**Method** setCorE(): Defines a correlation structure for default error variances. You must call setVarE first to define the default error variances.

**Usage:**
SimParam$setCorE(corE)

**Arguments:**
- **corE** a correlation matrix for the error variances

**Examples:**

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10, mean=c(0,0), var=c(1,1), corA=diag(2))
SP$setVarE(varE=c(1,1))
E = 0.5*diag(2)+0.5 #Positively correlated error
SP$setCorE(E)
```

**Method** rescaleTraits(): Linearly scales all traits to achieve desired values of means and variances in the founder population.

**Usage:**

```r
```
SimParam$rescaleTraits(
    mean = 0,
    var = 1,
    varEnv = 0,
    varGxE = 1e-06,
    useVarA = TRUE
)

Arguments:
mean  a vector of new trait means
var   a vector of new trait variances
varEnv a vector of new environmental variances
varGxE a vector of new GxE variances
useVarA tune according to additive genetic variance if true

Examples:
#Create founder haplotypes
defounderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

#Create population
defop = newPop(founderPop, simParam=SP)
meanG(pop)

#Change mean to 1
SP$rescaleTraits(mean=1)
#Run resetPop for change to take effect
defop = resetPop(pop, simParam=SP)
meanG(pop)

Method setRecombRatio(): Set the relative recombination rates between males and females. This allows for sex-specific recombination rates, under the assumption of equivalent recombination landscapes.

Usage:
SimParam$setRecombRatio(femaleRatio)

Arguments:
femaleRatio relative ratio of recombination in females compared to males. A value of 2 indicate twice as much recombination in females. The value must be greater than 0. (default is 1)

Examples:
#Create founder haplotypes
defounderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$setRecombRatio(2) #Twice as much recombination in females
Method switchGenMap(): Replaces existing genetic map.

Usage:
SimParam$switchGenMap(genMap, centromere = NULL)

Arguments:
- genMap: a list of length nChr containing numeric vectors for the position of each segregating site on a chromosome.
- centromere: a numeric vector of centromere positions. If NULL, the centromere are assumed to be metacentric.

Method switchFemaleMap(): Replaces existing female genetic map.

Usage:
SimParam$switchFemaleMap(genMap, centromere = NULL)

Arguments:
- genMap: a list of length nChr containing numeric vectors for the position of each segregating site on a chromosome.
- centromere: a numeric vector of centromere positions. If NULL, the centromere are assumed to be metacentric.

Method switchMaleMap(): Replaces existing male genetic map.

Usage:
SimParam$switchMaleMap(genMap, centromere = NULL)

Arguments:
- genMap: a list of length nChr containing numeric vectors for the position of each segregating site on a chromosome.
- centromere: a numeric vector of centromere positions. If NULL, the centromere are assumed to be metacentric.

Method addToRec(): For internal use only.

Usage:
SimParam$addToRec(lastId, id, mother, father, isDH, hist, ploidy)

Arguments:
- lastId: ID of last individual
- id: the name of each individual
- mother: vector of mother iids
- father: vector of father iids
- isDH: indicator for DH lines
- hist: new recombination history
- ploidy: ploidy level

Method ibdHaplo(): For internal use only.

Usage:
SimParam$ibdHaplo(iid)

Arguments:
iid  internal ID

**Method** `updateLastId()`: For internal use only.

*Usage:*

`SimParam$updateLastId(lastId)`

*Arguments:*

`lastId` last ID assigned

**Method** `addToPed()`: For internal use only.

*Usage:*

`SimParam$addToPed(lastId, id, mother, father, isDH)`

*Arguments:*

`lastId` ID of last individual
`id` the name of each individual
`mother` vector of mother iids
`father` vector of father iids
`isDH` indicator for DH lines

**Method** `clone()`: The objects of this class are cloneable with this method.

*Usage:*

`SimParam$clone(deep = FALSE)`

*Arguments:*

`deep` Whether to make a deep clone.

**Note**

By default the founder population is the population used to initialize the SimParam object. This population can be changed by replacing the population in the founderPop slot. You must run `resetPop` on any existing populations to obtain the new trait values.

**Examples**

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
```
#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$setTrackPed(TRUE)

## Method `SimParam=setTrackPed`

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$setTrackRec(TRUE)

## Method `SimParam=setTrackRec`

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)

#Create population
pop = newPop(founderPop, simParam=SP)
pop@id # 1:10

#Create another population after resetting pedigree
SP$resetPed()
pop2 = newPop(founderPop, simParam=SP)
pop2@id # 1:10

## Method `SimParam=resetPed`

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$restrSegSites(minQtlPerChr=5, minSnpPerChr=5)

## Method `SimParam=restrSegSites`

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)

#Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$setSexes("yes_sys")

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addSnpChip(10)

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAG(10, varGxE=2)

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitADG(10)
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitADG(10, meanDD=0.5, varGxE=2)

## Method 'SimParam$addTraitAE'

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

## Method 'SimParam$addTraitADE'

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitADE(10)

## Method 'SimParam$addTraitAEG'

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAEG(10, varGxE=2)

## Method 'SimParam$addTraitADEG'

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitADEG(10, meanDD=0.5, varGxE=2)

## Method 'SimParam$setVarE'

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)

## ----------------------------------------
## Method `SimParam$setCorE`
## ----------------------------------------

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10, mean=c(0,0), var=c(1,1), corA=diag(2))
SP$setVarE(varE=c(1,1))
E = 0.5*diag(2)+0.5 #Positively correlated error
SP$setCorE(E)

## ----------------------------------------
## Method `SimParam$setCorE`
## ----------------------------------------

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

# Create population
pop = newPop(founderPop, simParam=SP)
meanG(pop)

# Change mean to 1
SP$setRecombRatio(2) #Twice as much recombination in females
### smithHazel

**Calculate Smith-Hazel weights**

#### Description

Calculates weights for Smith-Hazel index given economic weights and phenotypic and genotypic variance-covariance matrices.

#### Usage

```r
decorator <- function(f) {
  return(smithHazel(econWt, varG, varP))
}
```

#### Arguments

- `econWt`: vector of economic weights
- `varG`: the genetic variance-covariance matrix
- `varP`: the phenotypic variance-covariance matrix

#### Value

A vector of weight for calculating index values

#### Examples

```r
G = 1.5*diag(2)-0.5
E = diag(2)
P = G+E
wt = c(1,1)
smithHazel(wt, G, P)
```

---

### TraitA-class

**Additive trait**

#### Description

Extends LociMap-class to model additive traits

#### Slots

- `addEff` additive effects
- `intercept` adjustment factor for gv
### TraitA2-class

**Description**

Extends TraitA-class to model separate additive effects for parent of origin. Used exclusively for genomic selection.

**Slots**

- `addEffMale` additive effects

### TraitA2D-class

**Description**

Extends TraitA2-class to add dominance

**Slots**

- `domEff` dominance effects

### TraitAD-class

**Description**

Extends TraitA-class to add dominance

**Slots**

- `domEff` dominance effects

### TraitADE-class

**Description**

Extends TraitAD-class to add epistasis

**Slots**

- `epiEff` epistatic effects
**TraitADEG-class**  
*Additive, dominance, epistasis, and GxE trait*

**Description**

Extends *TraitADE-class* to add GxE effects

**Slots**

- `gxeEff`  GxE effects
- `gxeInt`  GxE intercept
- `envVar`  Environmental variance

---

**TraitADG-class**  
*Additive, dominance and GxE trait*

**Description**

Extends *TraitAD-class* to add GxE effects

**Slots**

- `gxeEff`  GxE effects
- `gxeInt`  GxE intercept
- `envVar`  Environmental variance

---

**TraitAE-class**  
*Additive and epistatic trait*

**Description**

Extends *TraitA-class* to add epistasis

**Slots**

- `epiEff`  epistatic effects
**TraitAEG-class**

Additive, epistasis and GxE trait

**Description**

Extends *TraitAE-class* to add GxE effects

**Slots**

- `gxeEff` GxE effects
- `gxeInt` GxE intercept
- `envVar` Environmental variance

**TraitAG-class**

Additive and GxE trait

**Description**

Extends *TraitA-class* to add GxE effects

**Slots**

- `gxeEff` GxE effects
- `gxeInt` GxE intercept
- `envVar` Environmental variance

**usefulness**

Usefulness criterion

**Description**

Calculates the usefulness criterion

**Usage**

```r
usefulness(pop,
            trait = 1,
            use = "gv",
            p = 0.1,
            selectTop = TRUE,
            simParam = NULL,
            ...
)
```
Arguments

- **pop**: and object of `Pop-class` or `HybridPop-class`
- **trait**: the trait for selection. Either a number indicating a single trait or a function returning a vector of length nInd.
- **use**: select on genetic values (gv, default), estimated breeding values (ebv), breeding values (bv), or phenotypes (pheno)
- **p**: the proportion of individuals selected
- **selectTop**: selects highest values if true. Selects lowest values if false.
- **simParam**: an object of `SimParam`
- **...**: additional arguments if using a function for trait

Value

Returns a numeric value

Examples

```r
#Create founder haplotypes
founderPop = quickHaplo(nInd=2, nChr=1, segSites=10)

#Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)

#Create population
pop = newPop(founderPop, simParam=SP)

#Determine usefulness of population
usefulness(pop, simParam=SP)

#Should be equivalent to GV of best individual
max(gv(pop))
```

---

**varA**

*Additive variance*

Description

Returns additive variance for all traits

Usage

```r
varA(pop, simParam = NULL)
```
Arguments

pop an object of `Pop-class`
simParam an object of `SimParam`

Examples

```
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

# Create population
pop = newPop(founderPop, simParam=SP)
varA(pop, simParam=SP)
```

---

**Description**

Returns additive-by-additive epistatic variance for all traits

**Usage**

```
varAA(pop, simParam = NULL)
```

**Arguments**

pop an object of `Pop-class`
simParam an object of `SimParam`

**Examples**

```
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

# Create population
pop = newPop(founderPop, simParam=SP)
varAA(pop, simParam=SP)
```
varD  

*Dominance variance*

**Description**

Returns dominance variance for all traits

**Usage**

```r
varD(pop, simParam = NULL)
```

**Arguments**

- `pop`: an object of `Pop-class`
- `simParam`: an object of `SimParam`

**Examples**

```r
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitAD(10, meanDD=0.5)
SP$setVarE(h2=0.5)

# Create population
pop = newPop(founderPop, simParam=SP)
varD(pop, simParam=SP)
```

---

varG  

*Total genetic variance*

**Description**

Returns total genetic variance for all traits

**Usage**

```r
varG(pop)
```

**Arguments**

- `pop`: an object of `Pop-class` or `HybridPop-class`
Examples

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)

# Create population
pop = newPop(founderPop, simParam=SP)
varG(pop)

---

**varP**

Phenotypic variance

Description

Returns phenotypic variance for all traits

Usage

varP(pop)

Arguments

pop an object of Pop-class or HybridPop-class

Examples

# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$addTraitA(10)
SP$setVarE(h2=0.5)

# Create population
pop = newPop(founderPop, simParam=SP)
varP(pop)
writePlink

**WritePlink**

---

**Description**

Writes a Pop-class as PLINK PED and MAP files

**Usage**

```r
writePlink(
  pop,
  baseName,
  trait = 1L,
  snpChip = 1L,
  simParam = NULL,
  chromLength = 10L^8
)
```

**Arguments**

- `pop` an object of **Pop-class**
- `baseName` a character. Basename of PED and MAP files.
- `trait` an integer. Which phenotype trait should be used.
- `snpChip` an integer. Which SNP array should be used.
- `simParam` an object of **SimParam**
- `chromLength` an integer. The size of chromosomes in base pairs; assuming all chromosomes are of the same size.

**Examples**

```r
## Not run:
# Create founder haplotypes
founderPop = quickHaplo(nInd=10, nChr=1, segSites=10)

# Set simulation parameters
SP = SimParam$new(founderPop)
SP$setSexes(sex = "yes_rand")
SP$addTraitA(nQtlPerChr = 10)
SP$addSnpChip(nSnpPerChr = 5)

# Create population
pop = newPop(rawPop = founderPop)
pop = setPheno(pop, varE = SP$varA)
writePlink(pop, baseName="test")

# Test
test = read.table(file = "test.ped")
```
writeRecords
#...sex
if (!identical(x = c("M", "F")[[test[[5]]]], y = pop@sex)) { stop() }
#...pheno (issues with rounding)
# if (!identical(x = test[[6]], y = pop@pheno[, 1])) { stop() }
#...genotypes
x = test[, -(1:6)] - 1
x[, 1] = x[, 1] + x[, 2]
x[, 2] = x[, 3] + x[, 4]
x[, 3] = x[, 5] + x[, 6]
x[, 4] = x[, 7] + x[, 8]
x[, 5] = x[, 9] + x[, 10]
y = pullSnpGeno(pop)
if (sum(x[, 1:5] - y)!= 0) { stop() }

## End(Not run)

writeRecords  Write data records

Description
Saves a population’s phenotypic and marker data to a directory.

Usage
writeRecords(
  pop,
  dir,
  snpChip = 1,
  useQtl = FALSE,
  includeHaplo = FALSE,
  append = TRUE,
  simParam = NULL
)

Arguments

pop  an object of Pop-class

dir  path to a directory for saving output

snpChip which SNP chip genotype to save. If useQtl=TRUE, this value will indicate which trait's QTL genotype to save. A value of 0 will skip writing a snpChip.

useQtl should QTL genotype be written instead of SNP chip genotypes.

includeHaplo should markers be separated by female and male haplotypes.

append if true, new records are added to any existing records. If false, any existing records are deleted before writing new records. Note that this will delete all files in the 'dir' directory.

simParam an object of SimParam
Index

[], HybridPop-method (HybridPop-class), 21
[], MapPop-method (MapPop-class), 25
[], MegaPop-method (MegaPop-class), 27
[], NamedMapPop-method (NamedMapPop-class), 30
[], Pop-method (Pop-class), 36
[], RawPop-method (RawPop-class), 46
[], MegaPop-method (MegaPop-class), 27

aa, 4
attrition, 5

bv, 5
c, HybridPop-method (HybridPop-class), 21
c, MapPop-method (MapPop-class), 25
c, MegaPop-method (MegaPop-class), 27
c, NamedMapPop-method (NamedMapPop-class), 30
c, Pop-method (Pop-class), 36
c, RawPop-method (RawPop-class), 46
calcGCA, 6
cChpl, 7
dd, 7
doubleGenome, 8, 24
ebv, 9
editGenome, 10
editGenomeTopQtl, 11
fastRRBLUP, 12
genicVarA, 13
genicVarAA, 14
genicVarD, 14
genicVarG, 15
genParam, 16
getQtlMap, 17
getSnpMap, 18
gv, 19

hybridCross, 20, 83, 84
HybridPop-class, 21
LociMap-class, 22
makeCross, 22, 44
makeCross2, 23, 45
makeDH, 20, 24, 79
MapPop-class, 25
meanG, 25
meanP, 26
MegaPop-class, 27
mergeGenome, 27
mergePops, 28
mutate, 29
NamedMapPop-class, 30
newMapPop, 31
newMegaPop, 32
newPop, 20, 32, 79
nInd, 33
pedigreeCross, 34
pheno, 35
Pop-class, 36
popVar, 37
pullIbdHaplo, 38
pullQtlGeno, 38
pullQtlHaplo, 39
pullSegSiteGeno, 40
pullSegSiteHaplo, 41
pullSnpGeno, 42
pullSnpHaplo, 42
quickHaplo, 43
randCross, 44, 66
randCross2, 45
RawPop-class, 46
reduceGenome, 24, 47
resetPop, 48, 97
RRBLUP, 12, 49, 50–52
RRBLUP2, 12, 50
RRBLUP_D, 53, 54
RRBLUP_D2, 54
RRBLUP_GCA, 52, 56, 57, 59
RRBLUP_GCA2, 57
RRBLUP_SCA, 52, 59, 60
RRBLUP_SCA2, 60
RRBLUPMemUse, 52
RRsol-class, 62
runMacs, 32, 62, 63, 64
runMacs2, 63
sampleHaplo, 65
selectCross, 66
selectFam, 67
selectInd, 66, 69, 74
selectOP, 70
selectWithinFam, 71
self, 73
selIndex, 74
selInt, 75
setEBV, 29, 75
setPheno, 29, 76
setPhenoGCA, 78
setPhenoProgTest, 79
show,Pop-method (Pop-class), 36
show,RawPop-method (RawPop-class), 46
smithHazel, 102
TraitA-class, 102
TraitA2-class, 103
TraitA2D-class, 103
TraitAD-class, 103
TraitADE-class, 103
TraitADEG-class, 104
TraitADG-class, 104
TraitAE-class, 104
TraitAEG-class, 105
TraitAG-class, 105
usefulness, 105
var, 37
varA, 106