

Package ‘mmod’

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Maintainer David Winter <david.winter@gmail.com>

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Description Provides functions for measuring
population divergence from genotypic data.

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URL <https://github.com/dwinter/mmod>

BugReports <https://github.com/dwinter/mmod/issues>

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Author David Winter [aut, cre],
Peter Green [ctb],
Zhian Kamvar [ctb],
Thierry Gosselin [ctb]

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as.genind.DNABin	<i>as.genind.DNABin</i>
------------------	-------------------------

Description

Convert a DNABin object into a genind object

Usage

```
as.genind.DNABin(x, pops)
```

Arguments

x	object of class DNABin
pops	vector of population assignments for each sequence

Value

genind

Examples

```
library(pegas)
data(woodmouse)
wm <- as.genind.DNABin(woodmouse, rep(c("A", "B", "C"), each=5))
diff_stats(wm)
```

chao_bootstrap	<i>Produce bootstrap samples from each subpopulation of a genind object</i>
----------------	---

Description

This function produces bootstrap samples from a genind object, with each subpopulation resampled according to its size. Because there are many statistics that you may wish to calculate from these samples, this function returns a list of genind objects representing bootstrap samples that can then be further processed (see examples).

Usage

```
chao_bootstrap(x, nreps = 1000)
```

Arguments

x	genind object (from package adegenet)
nreps	numeric number of bootstrap replicates to perform (default 1000)

Details

You should note, this is a standard (frequentist) approach to quantifying uncertainty - effectively asking "if the population was exactly like our sample, and we repeatedly took samples like this from it, how much would those samples vary?" The confidence intervals don't include uncertainty produced from any biases in the way you collected your data. Additionally, this bootstrapping procedure displays a slight upward bias for some datasets. If you plan on reporting a confidence interval for your statistic, it is probably a good idea to subtract the difference between the point estimate of the statistic and the mean of the bootstrap distribution from the extremes of the interval (as demonstrated in the example below)

Value

A list of genind objects

References

Chao, A. et al. (2008). A Two-Stage probabilistic approach to Multiple-Community similarity indices. *Biometrics*, 64:1178-1186

See Also

Other resample: [jackknife_populations](#), [summarise_bootstrap](#)

Examples

```
## Not run:
data(nancycats)
obs.D <- D_Jost(nancycats)
bs <- chao_bootstrap(nancycats)
bs_D <- summarise_bootstrap(bs, D_Jost)
bias <- bs.D$summary.global.het[1] - obs.D$global.het
bs.D$summary.global.het - bias

## End(Not run)
```

diff_stats

*Calculate differentiation statistics for a genind object***Description**

By default this function calculates three different statistics of differentiation for a genetic dataset. Nei's G_{ST} , Hedrick's G''_{ST} and Jost's D . Optionally, it can also calculate Φ_{ST} , which is not calculated by default as it can take somewhat more time to run.

Usage

```
diff_stats(x, phi_st = FALSE)
```

Arguments

x	genind object (from package adegenet)
phi_st	Boolean Calculate Φ_{ST} (default is FALSE)

Details

See individual functions (listed below) for more details.

Value

per.locus values for each statistic for each locus in the dataset
 global estimates for these statistics across all loci in the dataset

References

- Hedrick, PW. (2005), A Standardized Genetic Differentiation Measure. *Evolution* 59: 1633-1638.
- Jost, L. (2008), G_{ST} and its relatives do not measure differentiation. *Molecular Ecology*, 17: 4015-4026.
- Meirmans PG, Hedrick PW (2011), Assessing population structure: F_{ST} and related measures. *Molecular Ecology Resources*, 11:5-18
- Nei M. (1973) Analysis of gene diversity in subdivided populations. *PNAS*: 3321-3323.

Nei M, Chesser RK. (1983). Estimation of fixation indices and gene diversities. *Annals of Human Genetics*. 47: 253-259.

Meirmans, PW. (2005), Using the AMOVA framework to estimate a standardized genetic differentiation measure. *Evolution* 60: 2399-402.

Excoffier, L., Smouse, P., Quattro, J. (1992), Analysis of molecular variance inferred from metric distances among DNA haplotypes: application to human mitochondrial DNA restriction data. *Genetics* 131: 479-91

See Also

Other diffstat: [D_Jost](#), [Gst_Hedrick](#), [Gst_Nei](#), [Phi_st_Meirmans](#)

Examples

```
data(nancycats)
diff_stats(nancycats)
```

diff_test

An exact test of population differentiation for genind objects

Description

This function uses Fisher's exact test to determine if alleles in sub-populations are drawn randomly from a larger population (i.e. a significance test for allelic differentiation among sub-populations).

Usage

```
diff_test(x, sim = TRUE, nreps = 2000)
```

Arguments

x	a genind object (from package adegenet)
sim	boolean: if TRUE simulate p-value by using an MCMC sample of those tables that have the same marginal totals as the observed data (required for all but the smallest datasets)
nreps	number of steps used to simulate p-value (default 2000)

Details

Note, this test returns p-values for each locus in a dataset `_not_` estimates of effect size. Since most populations have some degree of population differentiation, very large samples are almost guaranteed to return significant results. Refer to estimates of the various differentiation statistics (D, G''ST and Phi'ST) to ascertain how meaningful such results might be.

Value

named vector of p-values testing the null hypothesis these samples were drawn from a panmictic population.

See Also

[fisher.test](#), which this function wraps

Examples

```
data(nancycats)
diff_test(seploc(nancycats)[[2]], nreps=100)
```

 dist.codom

Calculate distance between individual for co-dominant locus

Description

This function calculates the distance between individuals in a `genind` object based on their genotypes. Specifically, the simple metric of Kosman and Leonard (2005) in which distance is calculated as a proportion of shared alleles at each locus.

Usage

```
dist.codom(x, matrix = TRUE, global = TRUE, na.rm = TRUE)
```

Arguments

<code>x</code>	genind object (from package <code>adegenet</code>)
<code>matrix</code>	boolean: if TRUE return matrix (dist object if FALSE)
<code>global</code>	boolean: if TRUE, return a single global estimate based on all loci. If FALSE return a list of matrices for each locus. if FALSE
<code>na.rm</code>	boolean: if TRUE remove individuals with NAs

Value

either a list of distance matrices, one for each locus or a single matrix containing the mean distance between individuals across all loci

Dropped for each distance matrix and object of class "na.action" containing indices to those individuals in the `genind` object which were omitted due to having NAs

References

Kosman E., Leonard, K.J. Similarity coefficients for molecular markers in studies of genetic relationships between individuals for haploid diploid, and polyploid species. *Molecular Ecology*. 14: 415-424

Examples

```
data(nancycats)
dm <- dist.codom(nancycats[40:45], matrix=FALSE)
head(dm)
```

D_Jost	<i>Calculate Jost's D</i>
--------	---------------------------

Description

This function calculates Jost's D from a genind object

Usage

```
D_Jost(x, hsht_mean = "arithmetic")
```

Arguments

x	genind object (from package adegenet)
hsht_mean	The type of mean to use to calculate values of Hs and Ht for a global estimate. (Default is the arithmetic mean, can also be set to the harmonic mean).

Details

Takes a genind object with population information and calculates Jost's D Returns a list with values for each locus as well as two global estimates. 'global.het' uses the averages of Hs and Ht across all loci while 'global.harm_mean' takes the harmonic mean of all loci.

Because estimators of Hs and Ht are used, its possible to have negative estimates of D. You should treat these as numbers close to zero.

Value

per.locus values for each D for each locus in the dataset

global estimates for D based on overall heterozygosity or the harmonic mean of values for each locus

References

Jost, L. (2008), GST and its relatives do not measure differentiation. *Molecular Ecology*, 17: 4015-4026.

See Also

Other diffstat: [Gst_Hedrick](#), [Gst_Nei](#), [Phi_st_Meirans](#), [diff_stats](#)

Other D: [pairwise_D](#)

Examples

```
data(nancycats)
D_Jost(nancycats)
D_Jost(nancycats, hsht_mean= "arithmetic")
```

Gst_Hedrick

Calculate Nei's G_{st} using estimators for H_s and H_t

Description

This function calculates Hedrick's G_{st} from a genind object

Usage

```
Gst_Hedrick(x)
```

Arguments

x genind object (from package adegenet)

Details

Takes a genind object with population information and calculates Hedrick's G_{st}.

Because estimators of H_s and H_t are used, it's possible to have negative estimates of G_{st}. You should treat such results as zeros (or an attempt to estimate a very low number with some error which might push it below zero)

Value

per.locus values for each G_{st} for each locus in the dataset
global estimates for G_{st} based on overall heterozygosity

References

Hedrick, PW. (2005), A Standardized Genetic Differentiation Measure. *Evolution* 59: 1633-1638.

Meirmans PG, Hedrick PW (2011), Assessing population structure: F_{ST} and related measures. *Molecular Ecology Resources*, 11:5-18

See Also

Other diffstat: [D_Jost](#), [Gst_Nei](#), [Phi_st_Meirmans](#), [diff_stats](#)

Other Hedrick: [pairwise_Gst_Hedrick](#)

Examples

```
data(nancycats)
Gst_Hedrick(nancycats)
```

`Gst_Nei`*Calculate Nei's Gst using estimators for Hs and Ht*

Description

This function calculates Gst following Nei's method and using Nei and Chesser's estimators for Hs and Ht

Usage

```
Gst_Nei(x)
```

Arguments

`x` genind object (from package adegenet)

Value

per.locus estimates of Gst for each locus in the dataset
per.locus estimates of Gst for across all loci

References

Nei M. (1973) Analysis of gene diversity in subdivided populations. PNAS: 3321-3323.

Nei M, Chesser RK. (1983). Estimation of fixation indices and gene diversities. Annals of Human Genetics. 47: 253-259.

See Also

Other diffstat: [D_Jost](#), [Gst_Hedrick](#), [Phi_st_Meirmons](#), [diff_stats](#)

Other Nei: [pairwise_Gst_Nei](#)

Examples

```
data(nancycats)  
Gst_Nei(nancycats)
```

harmonic_mean *Harmonic mean*

Description

Calculate the harmonic mean of a numeric vector (will return NA if there are any negative numbers in the vector)

Usage

```
harmonic_mean(x, na.rm = TRUE)
```

Arguments

x numeric vector
na.rm logical remove NAs prior or calculation

Value

harmonic mean of vector

Examples

```
data(nancycats)  
pop.sizes <- table(pop(nancycats))  
harmonic_mean(pop.sizes)
```

jackknife_populations *Create jackknife samples of a genind object by population*

Description

Makes a series of jackknife samples across populations from a genind object. This function returns a list of genind objects that can then be further processed (see examples below).

Usage

```
jackknife_populations(x, sample_frac = 0.5, nreps = 1000)
```

Arguments

x genind object (from package adegenet)
sample_frac fraction of pops to sample in each replication (default 0.5)
nreps number of jackknife replicates to run (default 1000)

Value

a list of `genind` objects to be further processed

See Also

Other resample: [chao_bootstrap](#), [summarise_bootstrap](#)

Examples

```
## Not run:
data(nancycats)
obs <- diff_stats(nancycats)
jn <- jackknife_populations(nancycats)
jn.D <- summarise_bootstrap(jn, D_Jost)

## End(Not run)
```

mmod

Modern Measures of Differentiation

Description

Population geneticists have traditionally used Nei's G_{ST} (often confusingly called F_{ST} ...) to measure divergence between populations. Recently, it has become clear that simple interpretations of the value of G_{ST} can be misleading. For this reason several new measures of differentiation have been developed. `mmod` is a package that brings some of these measures to R.

Details

The vignette for this package (available using `vignette("demo", package="mmod")` from within R) contains an introduction to these methods and an example usage for this package. I strongly suggest new users start by reading this documentation.

pairwise_D

Calculates pairwise values of Jost's D

Description

This function calculates Jost's D , a measure of genetic differentiation, between all combinations of populations in a `genind` object.

Usage

```
pairwise_D(x, linearized = FALSE, hsht_mean = "arithmetic")
```

Arguments

x	genind object (from package adegenet)
linearized	logical, if TRUE will turned linearized D (1/1-D)
hsht_mean	type of mean to use for the global estimates of Hs and Ht default it "arithmetic", can also be set to "harmonic".

Value

A distance matrix with between-population values of D

References

Jost, L. (2008), GST and its relatives do not measure differentiation. *Molecular Ecology*, 17: 4015-4026.

See Also

Other pairwise: [pairwise_Gst_Hedrick](#), [pairwise_Gst_Nei](#)

Other D: [D_Jost](#)

Examples

```
data(nancycats)
pairwise_D(nancycats[1:26,])
```

pairwise_Gst_Hedrick *Calculates pairwise values of Hedrick's G'st*

Description

This function calculates Hedrick's G'st, a measure of genetic differentiation, between all combinations of populations in a genind object.

Usage

```
pairwise_Gst_Hedrick(x, linearized = FALSE)
```

Arguments

x	genind object (from package adegenet)
linearized	logical, if TRUE will turned linearized G'st (1/(1-G'st))

Value

A distance matrix with between-population values of G'st

References

Hedrick, PW. (2005), A Standardized Genetic Differentiation Measure. *Evolution* 59: 1633-1638.

See Also

Other pairwise: [pairwise_D](#), [pairwise_Gst_Nei](#)

Other Hedrick: [Gst_Hedrick](#)

Examples

```
data(nancycats)
pairwise_Gst_Hedrick(nancycats[1:26,])
```

pairwise_Gst_Nei	<i>Calculates pairwise values of Nei's Gst</i>
------------------	--

Description

This function calculates Nei's Gst, a measure of genetic differentiation, between all combinations of populations in a genind object.

Usage

```
pairwise_Gst_Nei(x, linearized = FALSE)
```

Arguments

x	genind object (from package adegenet)
linearized	logical, if TRUE will be turned linearized Gst ($1/(1-Gst)$)

Value

dist A distance matrix with between-population values of Gst

References

Nei M. (1973) Analysis of gene diversity in subdivided populations. *PNAS*: 3321-3323.

Nei M, Chesser RK. (1983). Estimation of fixation indices and gene diversities. *Annals of Human Genetics*. 47: 253-259.

See Also

Other pairwise: [pairwise_D](#), [pairwise_Gst_Hedrick](#)

Other Nei: [Gst_Nei](#)

Examples

```
data(nancycats)
pairwise_Gst_Nei(nancycats[1:26,])
```

Phi_st_Meirmans *Calculate Phi_st from a genind object*

Description

This function calculates Meirmans' corrected version of Phi_st, an Fst analog produced using the AMOVA framework. Note, the global estimate produced by this function is calculated as the mean distance between individuals across all loci, and this excluded individuals with one or more missing value.

Usage

```
Phi_st_Meirmans(x)
```

Arguments

x genind object (from package adegenet)

Value

per.locus Phi_st estimate for each locus
global Phi_st estimate across all loci

References

Meirmans, PW. (2005), Using the AMOVA framework to estimate a standardized genetic differentiation measure. *Evolution* 60: 2399-402.

Excoffier, L., Smouse, P., Quattro, J. (1992), Analysis of molecular variance inferred from metric distances among DNA haplotypes: application to human mitochondrial DNA restriction data. *Genetics* 131: 479-91

See Also

Other diffstat: [D_Jost](#), [Gst_Hedrick](#), [Gst_Nei](#), [diff_stats](#)

Examples

```
data(nancycats)
Phi_st_Meirmans(nancycats[1:26,])
```

rgenotypes	<i>Randomly create genotypes</i>
------------	----------------------------------

Description

Use the multinomial distribution to randomly create genotypes for individuals for given allele frequencies. By default this function returns a matrix of with alleles in rows and individuals in columns. There is an option to return a genind object representing the same data (see examples).

Usage

```
rgenotypes(n, ploidy, probs, genind = FALSE, pop_name = "A",  
           loc_name = "L1")
```

Arguments

n	integer number of individuals.
ploidy	integer number of alleles to assign to each individual.
probs	vector of probabilities corresponding to allele frequencies.
genind	boolean if TRUE return a genind object
pop_name	character Name for population defined in genind object (not required if genind is not TRUE)
loc_name	character name to give locus in genind object

Details

Used in [chao_bootstrap](#), also exported as it may come in handy for other simulations.

Value

Either a matrix with individuals in columns, alleles in rows or, if genind is TRUE a genind object for one population and locus.

See Also

[rmultinom](#) which this function wraps.

Examples

```
data(nancycats)  
obs_allele_freqs <- apply(nancycats$tab[,1:16], 2, mean, na.rm=TRUE)  
rgenotypes(10, 2, obs_allele_freqs)
```

summarise_bootstrap *Apply a differentiation statistic to a bootstrap sample*

Description

This function applies a differentiation statistic (eg, `D_Jost`, `Gst_Hedrick` or `Gst_Nei`) to a list of `genind` objects, possibly produced with `chao_bootstrap` or `jackknife_populations`.

Usage

```
summarise_bootstrap(bs, statistic)
```

Arguments

<code>bs</code>	list of <code>genind</code> objects
<code>statistic</code>	differentiation statistic to apply (the function itself, as with <code>apply</code> family functions)

Details

Two different approaches are used for calculating confidence intervals in the results. The estimates given by `lower.percentile` and `upper.percentile` are simply the 2.5th and 97.5th percentile of the statistic across bootstrap samples. Note, the presence or rare alleles in some populations can bias bootstrapping procedures such that these intervals are not centered on the observed value. The mean of statistic across samples is returned as `mean.bs` and can be used to correct biased bootstrap samples. Alternatively, `lower.normal` and `upper.normal` form a confidence interval centered on the observed value of the statistic and using the standard deviation of the statistic across replicates to generate limits (sometimes called the normal-method of obtaining a confidence interval). The print function for objects returned by this function displays the normal-method confidence intervals.

Value

`per.locus`: matrix of statistics calculated for each locus (column) and each bootstrap replicate (row).
`global.het`: vector of global estimates calculated from overall heterozygosity
`global.het`: vector of global estimates calculated from harmonic mean of statistic (only applied to `D_Jost`)
`summary.loci`: data.frame summarising the distribution of the chosen statistic across replicates. Details of the different confidence intervals are given in details
`summary.global_het`: A vector containing the same measures as `summary.loci` but for a global value of the statistic calculated from all loci
`summary.global_harm`: As with `summary.global_het` but calculated from the harmonic mean of the statistic across loci (only applies to `D_Jost`)

See Also

Other resample: [chao_bootstrap](#), [jackknife_populations](#)

Examples

```
## Not run:  
data(nancycats)  
bs <- chao_bootstrap(nancycats)  
summarise_bootstrap(bs, D_Jost)  
  
## End(Not run)
```

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