Package ‘indicspecies’

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Author Miquel De Caceres, Florian Jansen
Maintainer Miquel De Caceres <miquelcaceres@gmail.com>
Description Functions to assess the strength and statistical significance of the relationship between species occurrence/abundance and groups of sites. Also includes functions to measure species niche breadth using resource categories.
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Description

This package provides a set of functions to assess the strength and statistical significance of the relationship between species occurrence/abundance and groups of sites. It is also possible to check the statistical significance of such associations. New functions have been added (previously distributed in ‘resniche’) which allow evaluate several niche metrics while accounting for distances between resources on the basis of the similar perception from species (De Cáceres et al. 2011).

Details

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Use strassoc for assessing strength of associations and signassoc to assess the statistical significance of the associations (De Cáceres & Legendre 2009). Much more complete functions are multipatt (De Cáceres et al. 2010) and indicators (De Cáceres et al. 2012). Read the package vignette using vignette("indicspeciesTutorial", package="indicspecies") to learn how to use this package.

Author(s)

Miquel De Cáceres, Florian Jansen

Maintainer: Miquel De Cáceres <miquelcaceres@gmail.com>

References


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### birds

**Description**

The resource use data for a set of 10 hypothetical bird species during two different seasons. There are five resource classes, and their relationships are given in matrix `resourceD`.

**Usage**

data(birds)

**Format**

`birdsbreed` - a data frame containing the resource use of 10 birds for a set of five resources during the breeding season.

`birdswinter` - a data frame containing the resource use of 10 birds for a set of five resources during the winter season.

`resourceD` - a distance matrix (object of class `dist`) containing the relationships between the five resources.

**Examples**

data(birds)

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### combinespecies

**Description**

Combines species from a community table

**Usage**

`combinespecies(X, max.order = 3, min.occ = 0, FUN = min, verbose = FALSE, add.names = TRUE, ...)`
combinespecies

Arguments

X A community data table with sites in rows and species in columns. This table can contain either presence-absence or abundance data.

max.order Maximum number of species conforming species combinations.

min.occ Threshold for minimum occurrence. Combinations with lower values are not kept.

FUN Function to be calculated for all species forming the species combination. Accepted values are \texttt{min}, \texttt{max}, \texttt{sum} and \texttt{mean}.

verbose If TRUE, prints the results of each step.

add.names If TRUE, adds the names of the species combinations to the output matrix. Species combination names are lists of species concatenated using character '+'.

... Additional arguments for function FUN.

Details

This function allows creating a data table where rows are sites and columns are combinations of species. Values for a given column of this matrix are derived from the abundance values of the species forming the corresponding combination. In particular, the abundance value for a given combination in a given site is equal to the value returned by function 'FUN' (normally the minimum) among the site values of all species forming the combination. The matrix ‘XC’ returned by this function can be used in functions \texttt{strassoc} and \texttt{signassoc}. Alternatively, \texttt{indicators} and related functions provide a more elaborated way to explore the indicator value of the simultaneous occurrence of sets of species (i.e. species combinations).

Value

An list with:

XC A matrix containing the abundance/occurrence of each species combination.

C A binary matrix describing the set of species forming each combination ('0' means that the species is not included, and '1' means that the species is included).

Author(s)

Miquel De Cáceres Ainsa, Biodiversity and Landscape Ecology Laboratory, Forest Science Center of Catalonia

References


See Also

\texttt{indicators}, \texttt{strassoc}, \texttt{signassoc}
Examples

```r
library(stats)

data(wetland) ## Loads species data

## Create species combinations
Y = combinespecies(X = wetland, max.order = 3, min.occ = 5, verbose = TRUE)

## Creates three site groups using kmeans
wetkm = kmeans(wetland, centers = 3)

## Calculate indicator value of species combinations for each of the three site groups
strassoc(Y$X, cluster = wetkm$cluster, func = "IndVal.g")

## Calculate point biserial correlation value of species combinations
## for each of the three site groups
strassoc(Y$X, cluster = wetkm$cluster, func = "r.g")
```

---

**coverage**

*Coverage of a set of indicators*

**Description**

Function `coverage` calculates the proportion of sites of the target site group where one or another indicator (a species or a species combination) is found. Parameters are used to select valid indicators before calculating coverage. Function `plotcoverage` plots the coverage against the positive predictive value threshold used to select indicators.

**Usage**

```r
coverage(x, y = NULL, selection = NULL, minstat = NULL, At = NULL, Bt = NULL, type = "stat", alpha = 0.05)
plotcoverage(x, y = NULL, by = 0.05, type = "stat", max.order = NULL, group = NULL, alpha = 0.05, add = FALSE, xlab = expression(A[t]), ...)
```

**Arguments**

- **x**: An object of class `indicators` or a community data table with sites in rows and species in columns (in this second case, an object of class `multipatt` must be supplied for `y`).
- **y**: An object of class `multipatt`.
- **selection**: A logical vector restricting the set of indicators used to calculate the coverage.
- **minstat**: Minimum value of the statistic for selecting indicators.
- **At**: Minimum value of positive predictive value (A) for selecting indicators.
- **Bt**: Minimum value for sensitivity (B) for selecting indicators.
alpha
Significance level for selecting indicators. This parameter is only used when the function is called using objects of class 'multipatt'.

type
Specifies how to select indicators: (1) using the value of the statistic (type = "stat"); (2) the lower bound of its confidence interval (type = "lowerCI"); or (3) the upper bound of its confidence interval (type = "upperCI"). This parameter makes sense when the function is called using objects of class 'indicators' and bootstrap confidence intervals are available for this object. Otherwise type has no effect and the value of the statistic is used for selection. In function coverage, the value of type applies to selection using minstat, At and Bt. In function plotcoverage, the value of type applies to selection using At.

by
Rate of increase in the predictive value threshold (At).

max.order
The maximum number of species conforming species combinations (allows examining the effects of increasing the order of combinations). This parameter is only used when the function is called using objects of class 'indicators'.

group
Either an integer or a character string indicating the site group or site group combination for which plot is desired. This parameter is only used when the function is called using objects of class 'multipatt'.

add
Flag indicating whether the function should draw on the existing plot.

xlab
Label for the x-axis.

Value
When used with an object of class 'indicators', function coverage returns the proportion of sites of the target site group where one or another indicator (species combination) is found. When used with an object of class 'indicators', function coverage returns a vector containing the coverage value for each site group or site group combination.
**indicators**

**Author(s)**

Miquel De Cáceres Ainsa, Biodiversity and Landscape Ecology Laboratory, Centre Tecnologic Forestal de Catalunya

**References**


**See Also**

`indicators, multipatt, pruneindicators`

**Examples**

```
library(stats)

data(wetland) ## Loads species data

## Creates three clusters using kmeans
wetkm = kmeans(wetland, centers=3)

## Determine sensitivity of individual species
B=strassoc(wetland, cluster=wetkm$cluster, func="B")

## Select species with more than 20% of sensitivity for the first group
sel=which(B[,1]>0.2)

## Run indicator analysis with species combinations for the first group
sc = indicators(X=wetland[,sel], cluster=wetkm$cluster, group=1, verbose=TRUE, At=0.5, Bt=0.2)

## Determine the coverage of the selected set of indicators
coverage(sc)

## Plot the coverage against the threshold At
plotcoverage(sc)
plotcoverage(sc, max.order=2, add=TRUE, lty=2)

## Runs the combination analysis using IndVal.g as statistic
wetpt = multipatt(wetland, wetkm$cluster, control = how(nperm=999))
## Determines the coverage for each site group combination
coverage(wetland, wetpt)
```

**indicators**

**Indicator analysis for species combinations**

**Description**

Determines the indicator value of species combinations.
Usage

indicators(X, cluster, group, func="IndVal", max.order=5, max.indicators=NULL,
At=0, Bt=0, sqrtIVt=0, nboot=0, alpha=0.05, XC=TRUE, enableFixed = FALSE, verbose = FALSE)
## S3 method for class 'indicators'
print(x, At=0, Bt=0, sqrtIVt=0, selection=NULL, confint=FALSE,...)
## S3 method for class 'indicators'
plot(x, type="sqrtIV", maxline=TRUE,...)
## S3 method for class 'indicators'
summary(object,...)

Arguments

X       A community data table with sites in rows and species in columns. This table
         can contain either presence-absence or abundance data.
x      An object of class 'indicators'.
object  An object of class 'indicators'.
cluster A vector containing the classification of sites into site groups.
group   The label corresponding to the target site group.
max.order Maximum number of species conforming species combinations.
max.indicators Maximum number of valid indicators to be kept. If NULL, then all valid indicators
         are kept.
func    The indicator value variant to be used, either "IndVal" (non-equalized) or "Ind-
         Val.g" (group-equalized).
At      Threshold for positive predictive value used to select valid indicators. Combi-
         nations with lower values are not kept.
Bt      Threshold for sensitivity used to select valid indicators. Combinations with
         lower values are not kept.
sqrtIVt Threshold for (square root of) indicator value. Combinations with lower values
         are not kept.
nboot   Number of bootstrap samples for confidence intervals.
alpha   Error in confidence intervals.
XC      If TRUE, outputs the abundance/occurrence matrix of species combinations.
enableFixed If TRUE, uses species that occur in all sites as fixed elements and creates com-
         binations with the remaining ones.
verbose If TRUE, prints the results of each step.
selection A logical vector used to restrict, a priori, the species combinations to be printed.
confint Flag to indicate that confidence interval bounds are desired when printing.
type Statistic to plot. Accepted values are "IV" (indicator value), "sqrtIV" (square
         root of indicator value), "A", "LA", "UA", (positive predictive value and confi-
         dence limits), "B", "LB", "UB" (sensitivity and confidence limits).
maxline Flag to indicate whether a line has to be drawn joining the maximum values for
         each order of combinations.
...  Additional arguments for functions print.summary or plot.
indicators

Details

Function *indicators* creates explores the indicator value of the simultaneous occurrence of sets of species (i.e. species combinations). The method is described in De Cáceres et al. (2012) and is a generalization of the Indicator Value method of Dufrêne & Legendre (1997). The maximum number of species conforming the species combination can be controlled using `max.order`. For each combination of species it determines its positive predictive value (A), sensitivity (B) and the square root of indicator value (sqrtIV). If `nboot>0` then bootstrap confidence intervals are determined with the specified `alpha` level, as explained in De Cáceres & Legendre (2009). The combinations to be kept can be restricted to those whose positive predictive value, sensitivity and/or indicator value are equal or greater than input thresholds. Function `print` allows printing the results in a nice table, whereas `summary` provides information about candidate species, combinations and coverage of the set of indicators. Function `plot` draws the statistics against the order (i.e. the number of species) of the combination.

Value

An object of class `indicators` with:

- `candidates` The vector of initial candidate species.
- `finalsplist` The vector of species finally selected for combinations.
- `C` A matrix describing all the combinations studied.
- `XC` A matrix containing the abundance/occurrence of each species combination.
- `A` Positive predictive power of species combinations. If `nboot>0` then this includes the lower and upper bounds of the confidence interval.
- `B` Sensitivity of species combinations. If `nboot>0` then this includes the lower and upper bounds of the confidence interval.
- `sqrtIV` Square root of indicator value of species combinations. If `nboot>0` then this includes the lower and upper bounds of the confidence interval.
- `group.vec` A logical vector indicating the membership to the target group.

Author(s)

Miquel De Cáceres Ainsa, Biodiversity and Landscape Ecology Laboratory, Forest Science Center of Catalonia

References


See Also

`predict.indicators,pruneindicators,coverage,multipatt,strassoc,signassoc`
Examples

```
library(stats)

data(wetland) ## Loads species data

## Creates three clusters using kmeans
wetkm = kmeans(wetland, centers=3)

## Determine sensitivity of individual species
B=stassoc(wetland, cluster=wetkm$cluster, func="B")

## Select species with more than 20% of sensitivity for the first group
sel=which(B[,1]>0.2)

## Run indicator analysis with species combinations for the first group
sc= indicators(X=wetland[,sel], cluster=wetkm$cluster, group=1, verbose=TRUE,
      At=0.5, Bt=0.2)

# Prints the results
print(sc)

## Plots positive predictive power and sensitivity against the order of
## combinations
plot(sc, type="A")
plot(sc, type="B")

## Run indicator analysis with species combinations for the first group,
## but forcing 'Orysp' to be in all combinations
sc2= indicators(X=wetland[,sel], cluster=wetkm$cluster, group=1, verbose=TRUE,
      At=0.5, Bt=0.2, enableFixed=TRUE)
```

### multipatt

**Multi-level pattern analysis**

**Description**

This function studies the association between species patterns and combinations of groups of sites.

**Usage**

```
multipatt(x, cluster, func = "IndVal.g", duleg=FALSE, restcomb=NULL,
    min.order = 1, max.order = NULL, control=how(),
    print.perm=FALSE)
```
**multipatt**

**Arguments**

- **x**: Community data table
- **cluster**: A vector representing a partition of sites
- **func**: Species-site group association function. Four values are accepted "IndVal", "IndVal.g", "r" and "r.g" (lowercase values are also accepted).
- **duleg**: If TRUE, site group combinations are not considered, only the original site groups, like in Dufrêne & Legendre (1997). Internally, duleg = TRUE equals max.order = 1.
- **restcomb**: A vector of integer values used to restrict the combinations of site groups to those with ecological sense according to the analyst. The default NULL indicates that all combinations are used. If duleg=TRUE this argument is ignored.
- **min.order**: An integer indicating the minimum order of site group combinations (by default max.order=1 for singletons). Cannot be larger than max.order.
- **max.order**: An integer indicating the maximum order of site group combinations to be considered: max.order=1 for singletons, max.order=2 for pairs, max.order=3 for triplets... As restcomb, this parameter provide a way to restrict the site group combinations that make ecological sense. By default all possible site group combinations are considered. If max.order=1 then the function will behave as if duleg=TRUE.
- **control**: a list of control values describing properties of the permutation design, as returned by a call to `how`.
- **print.perm**: If TRUE, prints permutation numbers after each set of 100 permutations.

**Details**

This function creates combinations of the input clusters and compares each combination with the species in the input matrix x. For each species it chooses the combination with a highest association value. Best matching patterns are tested for statistical significance of the associations. Four association indices are possible (some less than for `strassoc`): "IndVal", "IndVal.g", "r" and "r.g". Indicator value indices will return the pattern that better matches the species observed pattern, whereas correlation indices will return the pattern that creates a highest inside/outside difference. Details are given in De Cáceres et al. (2010). The user can restrict the combinations in three ways: (1) by using duleg=TRUE, which leads to consider single site-groups only; (2) by setting the minimum and maximum order of combinations using min.order and max.order; or (3) by using restcomb to restrict combinations at will. In order to carry out the third way, values in restcomb must be the indices of combinations that appear in the column index of object sign (see below). Complex permutation designs are allowed through the function `how` from package "permute".

**Value**

An object of class multipatt with:

- **func**: The name of the function used.
- **comb**: A matrix describing all the combinations studied.
- **str**: A matrix the association strength for all combinations studied.
If `func = "IndVal"` (or `func = "IndVal.g"`) a matrix whose values are the "A" (or "A.g") component of indicator values. Otherwise this element is left as NULL.

If `func = "IndVal"` (or `func = "IndVal.g"`) a matrix whose values are the "B" component of indicator values. Otherwise this element is left as NULL.

Data table with results of the best matching pattern, the association value and the degree of statistical significance of the association (i.e. p-values from permutation test). Note that p-values are not corrected for multiple testing.

Note

This function gives the same results as function `indval` in package "labdsv" when used setting `func="IndVal.g"` and `duleg=TRUE`, excepting the fact that the square root IndVal values is returned instead of the original IndVal.

Author(s)

Miquel De Cáceres Ainsa, Biodiversity and Landscape Ecology Laboratory, Forest Science Center of Catalonia

Florian Jansen, Institute of Botany and Landscape Ecology, Ernst-Moritz-Arndt-University

References


See Also

`summary.multipatt, strassoc, signassoc, how`

Examples

```r
library(stats)

data(wetland) # Loads species data

wetkm = kmeans(wetland, centers=3) # Creates three clusters using kmeans

# Runs the combination analysis using IndVal.g as statistic
wetpt = multipatt(wetland, wetkm$cluster, control = how(nperm=999))

# Lists those species with significant association to one combination
summary(wetpt)

# Lists those species with significant association to one combination,
```
nicheoverlap

## Metrics to compare pairs of resource niches

**Description**

Functions `nicheoverlap` and `nichedispl` compute the overlap and centroid distance between pairs of resource distributions. In both cases resource relationships are given in the distance matrix `d` and the resource use data are given in data frame `P1` (and in some modes also `P2`).

**Usage**

```r
nicheoverlap(P1, P2 = NULL, D = NULL, q1 = NULL, q2 = NULL, mode = "multiple", Np1 = NULL, Np2 = NULL, Nq1 = NULL, Nq2 = NULL, nboot = 1000, alpha=0.05)
nichedispl(P1, P2 = NULL, D = NULL, q1 = NULL, q2 = NULL, mode = "multiple", Np1 = NULL, Np2 = NULL, Nq1 = NULL, Nq2 = NULL, nboot = 1000, alpha=0.05)
```

**Arguments**

- `P1`: Data frame containing the amount of usage that a set of species (in rows) make of a first set of resources (in columns).
- `P2`: Data frame containing the amount of usage that a set of species (in rows) make of a second set of resources (in columns). Not used if `mode = "pairwise"`.
- `D`: Object of type `dist` containing distance values between resources. If no distance matrix is provided (i.e. if `D=NULL`), the distances between resources is assumed to be maximum.
- `q1`: Vector with the availability of each resource corresponding to `P1`.
- `q2`: Vector with the availability of each resource corresponding to `P2`.
- `mode`: Either `mode = "single"` (rows of matrices `P1` and `P2` are individual observations to be pooled, for example to compare the niche of two species each with its individual observations), `mode = "multiple"` (each row in `P1` is compared to the corresponding row of `P2`, for example, to compare seasonal niche shifts in each species) or `mode = "pairwise"` (all rows in `P1` are compared pairwise).
- `Np1`: Vector with the number of observations per species from which the values in `P1` come (in `mode = "multiple"` or `mode = "pairwise"`).
- `Np2`: Vector with the number of observations per species from which the values in `P2` come (only in `mode = "multiple"`).
- `Nq1`: The number of observations from which the values in `q1` come.
- `Nq2`: The number of observations from which the values in `q2` come.
- `nboot`: Number of bootstrap samples used to compute bias-corrected percentile confidence intervals.
- `alpha`: Used to set the confidence level (i.e. `alpha = 0.05` means 95 percent confidence interval).
Details

The method is described in De Caceres et al. (2011). If the distance matrix is not specified (i.e. if \( D=NULL \)) the function assumes that all resources are at a maximum distance (\( d=1 \)). If the resource availability vector \( q1 \) (and \( q2 \) if supplied) is specified, then the values in \( P1 \) (and \( P2 \) if supplied) are taken as assessments of resource use and the species preference is calculated taking into account resource availability. Otherwise, resource use is equated to resource preference (i.e. all resources are considered equally available). The functions can compute bootstrap confidence intervals following the bias-corrected percentile method (Manly 2007). If \( mode = "multiple" \) and \( np1 \) and \( np2 \) are not null, bootstrap samples for a given niche are generated assuming a multinomial distribution with the proportions calculated from the corresponding row values in \( P1 \) (resp. \( P2 \)), and the number of observations comes from the corresponding element in \( np1 \) (resp. \( np2 \)). Similarly, if \( mode = "pairwise" \) and \( np1 \) is not null, bootstrap samples for each niche are generated assuming a multinomial distribution with the proportions calculated from the corresponding row values in \( P1 \), and the number of observations comes from the corresponding element in \( np1 \). Finally, if \( mode = "single" \) then the bootstrapped units are the rows of matrices \( P1 \) and \( P2 \). In both cases, if \( Nq1 \) (and \( Nq2 \)) is indicated, the availability of resources is also bootstrapped. The bias-corrected percentile method is described for overlap niche measures in Mueller and Altenberg (1985).

Value

Function \code{nicheoverlap} (resp. \code{nichedispl}) returns the overlap (resp. the distance between centroids) between the each pair of rows in \( P1 \) and \( P2 \). If \( mode = "multiple" \) or \( mode = "single" \) the values are returned as a data frame. If \( mode = "pairwise" \) a matrix of values is returned instead. If bootstrap confidence intervals are asked then the functions also compute the lower and upper bounds of a confidence interval obtained following the bias-corrected percentile method. Upper and lower bounds are returned as additional columns of the data frame in \( mode = "multiple" \) or \( mode = "single" \) or as additional matrices of a list in \( mode = "pairwise" \).

Author(s)

Miquel De Caceres Ainsa

References


See Also

See \code{nichevar} for descriptors of single niches.

Examples

```r
# Loads example data
data(birds)
```
# The overlap and displacement metrics using distances among resources and assuming equal availability of resources

```r
nicheoverlap(birdsbreed, birdswinter, D = resourceD, mode="multiple")
nichedispl(birdsbreed, birdswinter, D = resourceD, mode="multiple")
```

# The overlap and displacement metrics using distances among resources and computes 95% percent confidence intervals

```r
nicheoverlap(birdsbreed, birdswinter, D = resourceD, mode="multiple",
            Np1 = rowSums(birdsbreed), Np2 = rowSums(birdswinter), Nq1 = 100, Nq2 = 100)
nichedispl(birdsbreed, birdswinter, D = resourceD, mode="multiple",
            Np1 = rowSums(birdsbreed), Np2 = rowSums(birdswinter), Nq1 = 100, Nq2 = 100)
```

# Same computations with different resource availability

```r
q = c(0.18, 0.24, 0.22, 0.21, 0.15)
nicheoverlap(birdsbreed, birdswinter, D = resourceD,
             q1 = q, q2 = q, mode="multiple")
nichedispl(birdsbreed, birdswinter, D = resourceD,
             q1 = q, q2 = q, mode="multiple")
nicheoverlap(birdsbreed, birdswinter, D = resourceD,
             q1 = q, q2 = q, mode="multiple",
            Np1 = rowSums(birdsbreed), Np2 = rowSums(birdswinter),
            Nq1 = 100, Nq2 = 100)
nichedispl(birdsbreed, birdswinter, D = resourceD,
             q1 = q, q2 = q, mode="multiple",
            Np1 = rowSums(birdsbreed), Np2 = rowSums(birdswinter),
            Nq1 = 100, Nq2 = 100)
```

# The overlap metrics using distances among rows of 'birdsbreed'

```r
n nicheoverlap(birdsbreed, D = resourceD, mode="pairwise")
```

### nichevar

#### Resource niche metrics for a single niche

**Description**

Function `nichepref` computes the species resource preference from the species resource use (and resource availability when given). Function `nichecentroid` computes the centroid on the resource space for a set of species. Function `nichevar` computes the multivariate resource variance for a set of species (i.e. niche breadth). In all functions resources are given in distance matrix `D`, the species resource use is given in `P` and the availability of resources, if present, are given by vector `q`.

**Usage**

```r
nichevar(P, D = NULL, q = NULL, mode="multiple", Np = NULL,
          Nq = NULL, nboot = 1000, alpha=0.05)
nichecentroid(P, D = NULL, q = NULL, mode="multiple", Np = NULL,
              Nq = NULL, nboot = 1000, alpha=0.05)
nichepref(P, D = NULL, q = NULL, mode="multiple", Np = NULL,
           Nq = NULL, nboot = 1000, alpha=0.05)
```
Arguments

- **P**: Data frame containing the relative or absolute usage that a set of species (in rows) make of a set of resources (in columns).
- **D**: Object of type `dist` containing distance values between resources. If no distance matrix is provided (i.e. if `D=NULL`), the distances between resources is assumed to be maximum.
- **q**: Vector with the availability of each resource.
- **mode**: Either `mode = "single"` (rows of matrix `P` are individual observations to be pooled for a single niche) or `mode = "multiple"` (rows in `P` represent different niches).
- **Np**: Vector with the number of observations per species from which the values in `P` come (in `mode = "multiple"`).
- **Nq**: The number of observations per species from which the values in `q` come (in `mode = "multiple"`).
- **nboot**: Number of bootstrap samples used to compute bias-corrected percentile confidence intervals.
- **alpha**: Used to set the confidence level (i.e. `alpha = 0.05` means 95 percent confidence interval).

Details

The method is described in De Caceres et al. (2010). If the distance matrix is not specified (i.e. if `D=NULL`) the function assumes that all resources are at a maximum distance (`d=1`). If the resource availability vector `q` is given then the values in `P` are taken as assessments of resource use and the species preference is calculated taking into account resource availability. Otherwise resource use is equated to resource preference. Moreover, most functions can compute bootstrap confidence intervals following the bias-corrected percentile method (Manly 2007). If `mode = "multiple"` and `Np != NULL`, bootstrap samples for a given species are generated assuming a multinominal distribution with the proportions calculated from the corresponding row values in `P`, and the number of observations comes from the corresponding element in `Np`. If `mode = "single"` then the bootstrapped units are the rows of matrix `P`. In both cases, if `Nq` is indicated the availability of resources is also bootstrapped. The bias-corrected percentile method was described for overlap niche measures in Mueller and Altenberg (1985) and is extended here for all niche metrics.

Value

Function `nichepref` returns a matrix of species relative preference. Function `nichevar` returns a vector with the variance of the resources used for each species in `P`. Function `nichecentroid` returns a matrix niche centroid in the resource space for each species in `df`. If bootstrap confidence intervals are asked then the three functions also compute two extra data containing respectively the lower and upper bounds of the confidence intervals obtained following the bias-corrected percentile method. Function `nichearea` returns the area of the convex hull occupied by the resources used for each species in `P`.

Author(s)

Miquel De Caceres Ainsa
nichevar

References


See Also

See nicheoverlap for descriptors comparing two niches.

Examples

# Loads example data
data(birds)

# The niche metrics using distances among resources and assuming equal availability of resources
nichepref(birdsbreed, D = resourceD)
nichevar(birdsbreed, D = resourceD)
nichecentroid(birdsbreed, D = resourceD)

# The niche metrics using distances among resources and computes
# 95 percent confidence intervals
nichepref(birdsbreed, D = resourceD, mode="multiple",
Np = rowSums(birdsbreed), Nq = 100)
nichevar(birdsbreed, D = resourceD, mode="multiple",
Np = rowSums(birdsbreed), Nq = 100)
nichecentroid(birdsbreed, D = resourceD, mode="multiple",
Np = rowSums(birdsbreed), Nq = 100)

# Same computations with different resource availability
nichepref(birdsbreed, D = resourceD,
q = c(0.18, 0.24, 0.22, 0.21, 0.15), mode="multiple")
nichevar(birdsbreed, D = resourceD,
q = c(0.18, 0.24, 0.22, 0.21, 0.15), mode="multiple")
nichecentroid(birdsbreed, D = resourceD,
q = c(0.18, 0.24, 0.22, 0.21, 0.15), mode="multiple")

# The niche metrics using distances among resources and
# computes 95 percent confidence intervals
nichepref(birdsbreed, D = resourceD,
q = c(0.18, 0.24, 0.22, 0.21, 0.15), mode="multiple", Np = rowSums(birdsbreed), Nq = 100)
nichevar(birdsbreed, D = resourceD,
q = c(0.18, 0.24, 0.22, 0.21, 0.15), mode="multiple", Np = rowSums(birdsbreed), Nq = 100)
nichecentroid(birdsbreed, D = resourceD,
q = c(0.18, 0.24, 0.22, 0.21, 0.15), mode="multiple", Np = rowSums(birdsbreed), Nq = 100)

# The following example defines a function to calculate the area of the niche
# It requires package 'rgeos'
library(rgeos)
nichesarea <- function (P, D = NULL, axes=c(1,2)) {
  if (is.null(D))
    D <- as.dist((matrix(1, ncol(P), ncol(P)) - diag(rep(1, ncol(P)))))
  cmd = cmdscale(D, eig=TRUE, k = ncol(P)-1)
  X = cmd$points
  V <- data.frame(Area=rep(0, nrow(P)))
  for (i in 1:nrow(P)) {
    pi = as.numeric(P[i,])
    if (is.na(sum(pi))) V[i,] <- NA
    else if (sum(pi) < 1e-16) V[i,] <- 0
    else if (sum(pi>0)==1) V[i,] <- 0
    else {
      a =X[pi>0,axes]
      V[i,] = area.poly(as(a[chull(a,], "gpc.poly")
    }
  }
  return(V)
}

nichesarea(birds.breed, D = resourceD)

---

pigeons  Pigeon seed consumption data

Description

Data set used for the dietary analysis of two feral pigeon (Columba livia) populations. There are six seed types, and their distance relationships are given in matrix dfood.

Usage

data(pigeons)

Format

diet.barcelona - a data frame containing the seed consumption (in grams) of pigeons taken from the population in Barcelona.
diet.moia - a data frame containing the seed consumption (in grams) of pigeons taken from the population in Moia.
dfood - a distance matrix (object of class dist) containing the relationships between the six seed types. Distances were calculated from data describing the nutritional content and dimensions of each seed type.

References


Examples

data(pigeons)
Function plotniche draws a resource niche on the resource space computed by means of principal coordinates analysis. Resource relationships are given in distance matrix D, the species resource use is given in P and the availability of resources is given by vector q.

**Usage**

```r
plotniche(P, D = NULL, q = NULL, mode = "multiple", Np = NULL,
Nq = NULL, nboot = 1000, alpha=0.05, species=NULL, axes=c(1,2),
chull=TRUE, bubbles=TRUE, writeName=FALSE, add=FALSE, col="black", lty=1,...)
```

**Arguments**

- **P**: Data frame containing the relative or absolute usage that a set of species (in rows) make of a set of resources (in columns).
- **D**: Object of type `dist` containing distance values between resources. If no distance matrix is provided (i.e. if `D=NULL`), the distances between resources is assumed to be maximum.
- **q**: Vector with the availability of each resource.
- **mode**: Either `mode = "single"` (rows of matrix P are individual observations to be pooled for a single niche) or `mode = "multiple"` (rows in P represent different niches).
- **Np**: Vector with the number of observations per species from which the values in P come (in mode = "multiple").
- **Nq**: The number of observations per species from which the values in q come.
- **nboot**: Number of bootstrap samples used to compute bias-corrected percentile confidence intervals.
- **alpha**: Used to set the confidence level (i.e. `alpha = 0.05` means 95 percent confidence interval).
- **species**: Specifies which species niche is to be plot. This parameter is mandatory and can be either an numeric index or a string for a species name.
- **axes**: PCoA axes used for plotting.
- **chull**: whether or not convex hulls should be drawn (only in type="single").
- **bubbles**: draws bubbles proportional to resource preference data.
- **writeName**: flag indicating whether or not the name of the species should be drawn beside the centroid.
- **col**: color of the centroid and confidence interval arrows.
- **lty**: line type of the confidence interval arrows.
- **add**: if TRUE, the current plot is used. This is helpful to draw more than one species on the same plot (see examples).
- **...**: additional graphical parameters.
Details

The method is described in De Caceres et al. (in prep). If the distance matrix is not specified (i.e. if \(d = \text{NULL}\)) the function assumes that all resources are at a maximum distance (\(d = 1\)). If the resource availability vector \(q\) is given then the values in \(P\) are taken as assessments of resource use and the species preference is calculated taking into account resource availability. Otherwise resource use is equated to resource preference. The function can also plot bootstrap confidence intervals following the bias-corrected percentile method (Manly 2007). If \(\text{mode} = \text{"multiple"}\) and \(\text{Np} \neq \text{NULL}\), bootstrap samples for a given species are generated assuming a multinomial distribution with the proportions calculated from the corresponding row values in \(P\), and the number of observations comes from the corresponding element in \(\text{Np}\). If \(\text{mode} = \text{"single"}\) then the bootstrapped units are the rows of matrix \(P\). In both cases, if \(\text{Nq}\) is indicated, the availability of resources is also bootstrapped. The bias-corrected percentile method was described for overlap niche measures in Mueller and Altenberg (1985) and is extended here for all niche metrics except \text{nichearea}.

Author(s)

Miquel De Caceres Ainsa

References


See Also

See \text{nichevar} and \text{nicheoverlap} to obtain a resource niche metrics.

Examples

# Loads example data
data(birds)

plotniche(birds$breed, D = resourceD, \text{mode} = \text{"multiple"}, \text{species} = 10)
plotniche(birds$breed, D = resourceD, \text{mode} = \text{"multiple"},
\text{Np} = \text{rowSums(birds$breed)}, \text{Nq} = 100, \text{species} = 10)
plotniche(birds$breed, D = resourceD,
q = \text{c(0.18, 0.24, 0.22, 0.21, 0.15)}, \text{mode} = \text{"multiple"}, \text{species} = 10)
plotniche(birds$breed, D = resourceD,
q = \text{c(0.18, 0.24, 0.22, 0.21, 0.15)}, \text{mode} = \text{"multiple"},
\text{Np} = \text{rowSums(birds$breed)}, \text{Nq} = 100, \text{species} = 10)

#draw two species
plotniche(birds$breed, D = resourceD, \text{mode} = \text{"multiple"},
\text{Np} = \text{rowSums(birds$breed)}, \text{Nq} = 100, \text{species} = 10, \text{writeName} = \text{TRUE},
\text{bubbles} = \text{FALSE}, \text{chull} = \text{FALSE})
plotniche(birds$breed, D = resourceD, \text{mode} = \text{"multiple"},
predict.indicators

Np = rowSums(birds$breed), Nq = 100, species=1, writeName=TRUE,
bubbles=FALSE, chull=FALSE, add=TRUE, col="red", lty=2)

predict.indicators Predicts site group from indicators

Description

Determines the probability of the indicated site group given a new community data set.

Usage

## S3 method for class 'indicators'
predict(object, newdata,...)

Arguments

object An object of class 'indicators'.
newdata A community data table (with sites in rows and species in columns) for which
predictions are needed. This table can contain either presence-absence or abundance data, but only presence-absence information is used for the prediction.

Additional arguments not used (included for compatibility with predict).

Details

Function indicators explores the indicator value of the simultaneous occurrence of sets of species (i.e. species combinations). The method is described in De Cáceres et al. (2012) and is a generalization of the Indicator Value method of Dufrêne & Legendre (1997). The current function predict.indicators is used to predict the indicated site group from the composition of a new set of observations. For communities where one or more of the indicator species combinations are found, the function returns the probability associated to the indicator that has the highest positive predictive value (if confidence intervals are available, the maximum value is calculated across the lower bounds of the confidence interval). For communities where none of the indicator species combinations is found, the function returns zeroes.

Value

If confidence intervals are available in x, the function returns a matrix where communities are in rows and there are three columns, corresponding to the probability of the indicated site group along with the confidence interval. If confidence intervals are not available in x, then the function returns a single vector with the probability of the indicated site group for each community.

Author(s)

Miquel De Cáceres Ainsa, Biodiversity and Landscape Ecology Laboratory, Forest Science Center of Catalonia
pruneindicators

References


See Also

indicators, pruneindicators coverage, multipatt, strassoc, signassoc

Examples

library(stats)

data(wetland) ## Loads species data

## Creates three clusters using kmeans
wetkm = kmeans(wetland, centers=3)

## Determine sensitivity of individual species
B=strassoc(wetland, cluster=wetkm$cluster, func="B")

## Select species with more than 20% of sensitivity for the first group
sel=which(B[,1]>0.2)

## Run indicator analysis with species combinations for the first group
sc= indicators(x=wetland[,sel], cluster=wetkm$cluster, group=1, verbose=TRUE, At=0.5, Bt=0.2)

## Use the indicators to make predictions
## (normally an independent data set will be used)
p<-predict(sc, wetland)

## Show original groups with prediction for group 1
print(data.frame(wetkm$cluster,p))

---

pruneindicators

Determines the best subset of indicators

Description

This function allows reducing drastically the number of species combinations to be retained for a given target site group.

Usage

pruneindicators(x, At=0, Bt=0, sqrtIVt=0, max.indicators=4, verbose=FALSE)
pruneindicators

Arguments

x An object of class 'indicators'.

At Threshold for positive predictive value. Combinations with lower values are not kept.

Bt Threshold for sensitivity. Combinations with lower values are not kept.

sqrtIVt Threshold for (square root of) indicator value. Combinations with lower values are not kept.

max.indicators Maximum number of species combinations to be kept. If NULL, the function returns all the non-nested valid indicators without further selection.

verbose If TRUE, prints the results of each step.

Details

First, the function selects those indicators (species or species combinations) with valid positive predictive value, sensitivity and indicator value, according to the input thresholds. If the object 'speciescomb' contains confidence intervals, then the lower bounds are used to select the valid indicators. Second, the function discards those valid indicators whose occurrence pattern is nested within other valid indicators. Third, the function evaluates the coverage of the remaining set of indicators and explores subsets of increasing number of indicators, until the same coverage is attained and the set of indicators is returned. If the maximum allowed members is attained (max.indicators) then the set of indicators with maximum coverage is returned.

Value

An object of class 'indicators' with only the species combinations selected.

Author(s)

Miquel De Cáceres Ainsa, Biodiversity and Landscape Ecology Laboratory, Forest Science Center of Catalonia

References


See Also

indicators, coverage

Examples

library(stats)

data(wetland) ## Loads species data
signassoc

**Statistical significance of species site-group associations**

**Description**

This function computes the permutation p-value of the association between a species vector and a vector of memberships to a site-group. Four different tests of hypotheses arise from considering either presence/absence or quantitative species data, and from using a non-equalized or group-equalized approach.

**Usage**

```r
signassoc(X, U = NULL, cluster = NULL, mode = 1, alternative = "greater", control = how(), print.perm = FALSE)
```

**Arguments**

- `X` species data (rows are sites, columns are species).
- `U` A matrix of group memberships. Each column corresponds to one site-group. Membership values can be crisp or fuzzy. If this matrix is not provided, vector `gmv` will be used.
- `cluster` a vector of numeric group labels for the sites.
- `mode` 0 (site-based) or 1 (group-based).
- `alternative` Alternative hypothesis: "greater" (positive association), "less" (negative association), "two.sided" (either positive or negative).
- `control` a list of control values describing properties of the permutation design, as returned by a call to `how`.
- `print.perm` If TRUE, prints permutation numbers after each set of 100 permutations.
**signassoc**

**Details**

Input data for this function is the species matrix X and either a matrix of group memberships (U) or a vector of numeric group labels (cluster). This R function works for both presence/absence and quantitative species data, depending on the values of the input matrix X. If mode = 0, the null ecological hypothesis is that the frequency (or abundance) of the species of interest in sites belonging to the site group is not higher than the frequency (or abundance) in sites not belonging to it. If mode = 1, the null ecological hypothesis is that the relative frequency (average abundance) of the species of interest is not higher in the target site group than in other groups. See De Cáceres and Legendre for more details. Complex permutation designs are allowed through the function `how` from package "permute".

**Value**

Returns a matrix of p-values, where species are in rows and groups are in columns. Two additional columns indicate the group with lowest p-value and the p-value for this group after Sidak’s correction for multiple testing.

**Note**

Users should be aware that the significance test in `signassoc` is not exactly the same as the one in `indval` from `labdsv` package. The `signassoc` function is using the preference for the target group (either non-equalized or group-equalized) as test statistic. After every permutation the preference for the target group is recalculated. The function is therefore testing the null hypothesis stating that the preference of the species for a given site group is due to chance only (as in Bakker 2008). The test is repeated for every group, and this is the reason why there are as many p-values as groups. In contrast, the `indval` function from `labdsv` package uses the maximum preference value as test statistic, and the maximum preference value is recalculated after each permutation. The maximum preference may correspond to other groups than the one chosen for the unpermuted data. `indval` function from `labdsv` package is therefore testing the null hypothesis saying that the group with observed maximum preference is not such, because the maximum preference was in that group due to chance only. In order to get the consistent results compared to the `indval` function, users should use the function `multipatt`, along with the option `duleg=TRUE`.

**Author(s)**

Miquel De Cáceres Ainsa, Biodiversity and Landscape Ecology Laboratory, Forest Science Center of Catalonia

**References**


**See Also**

`strassoc`, `multipatt`, `how`
Examples

library(stats)

data(wetland) # Load species data

wetkm = kmeans(wetland, centers=3)# Create three clusters using

## Look for species whose abundance is significantly higher in one of the three groups
signassoc(wetland, cluster=wetkm$cluster, mode=1, control = how(nperm=999))

## Look for species whose abundance is significantly higher in sites belonging
## to one group as opposed to sites not belonging to it.
signassoc(wetland, cluster=wetkm$cluster, mode=0, control = how(nperm=999))

strassoc  Strength of species site-group associations

Description

This function computes the strength of the association between a species vector and a vector of
memberships to the site-group. Several statistics are possible, following De Cáceres and Legen-
dre (2009). The choice of the most appropriate statistic depends on the application. If required, bootstrap confidence interval bounds are also computed.

Usage

strassoc(X, cluster, func = "r", group = NULL, nboot = 0, alpha = 0.05, c = 1)

Arguments

X species data (rows are sites, columns are species).

cluster a vector of numeric group labels for the sites.

func the association index to be used. Accepted function names: "r", "r.g", "IndVal",
"IndVal.g", "A", "A.g", "B", "cos", "cos.g", "r.ind", "r.ind.g", "s.ind", "s.ind.g"
(lowercase values are also accepted).

group Group for which association values are to be computed. If group=NULL, asso-
ciation values will be computed for all groups.

nboot Number of bootstrap samples.

alpha Error in confidence intervals

c Total abundance per site (used in functions "r.ind", "r.ind.g", "s.ind", "s.ind.g"
only).
Details

This R function is applicable to both presence-absence and quantitative species data, depending on the values in the input matrix X. Indices "r","r.g","cos" and "cos.g" correspond to the general correlation generalization ("r" is the point-biserial correlation coefficient), whereas "r.ind", "r.ind.g", "s.ind" and "s.ind.g" correspond to the individual-based generalization. Both approaches give the same results for binary (presence-absence) species data. Indicator value indices "IndVal" and "IndVal.g" are partial generalizations of the indices of the presence-absence indices. The "IndVal" index of Dufrêne & Legendre (1997) is called "IndVal.g" here and strassoc returns the square root of the original index. Indices "A","A.g" and "B" are the asymmetric quantities into which indicator values "IndVal" and "IndVal.g" can be decomposed. See De Cáceres and Legendre for details on the relationships between these indices and their usage. Bootstrap confidence intervals are computed using the simple percentile method (Manly 1997).

Value

Returns a matrix of association values, where species are in rows and groups are in columns. If 'nboot' is non zero, then a list is returned, where 'stat' contains the matrix of association values, and the lower and upper confidence limits are given in supplementary matrices named 'lowerCI' and 'upperCI' respectively.

Note

This function gives the same association values as function indval in package "labdsv" when used setting func="IndVal.g", excepting the fact that the square root IndVal values is returned instead of the original IndVal.

Author(s)

Miquel De Cáceres Ainsa, Biodiversity and Landscape Ecology Laboratory, Centre Tecnologic Forestal de Catalunya

References


See Also

signassoc, multipatt

Examples

```r
## Load species data
data(wetland)
```
## Create three clusters using
```r
cclusters = kmeans(wetland, centers=3)
```

## Compute Dufrene and Legendre's IndVal
```r
strassoc(wetland, cclus$L, func="IndVal.g")
```

## Compute point-biserial correlation, with bootstrap 95 percent confidence intervals
```r
strassoc(wetland, wetkm$L$cluster, func="r", nboot = 100)
```

---

**summary.multipatt**

**Summary multi-level pattern analysis**

### Description

This is a summary function for `multipatt` objects.

### Usage

```r
## S3 method for class 'multipatt'
summary(object, alpha=0.05, minstat=NULL, At = NULL, Bt=NULL, indvalcomp=FALSE, ...)
```

### Arguments

- **object**: An object returned by function `multipatt`.
- **alpha**: Significance level for selecting species in the summary.
- **minstat**: Minimum value of the statistic for selecting species in the summary.
- **At**: Minimum value of positive predictive value (A) for selecting indicators. This argument is effective only if `multipatt` function was executed using `func = "IndVal"` or `func = "IndVal.g"`.
- **Bt**: Minimum value for sensitivity (B) for selecting indicators. This argument is effective only if `multipatt` function was executed using `func = "IndVal"` or `func = "IndVal.g"`.
- **indvalcomp**: Flag used to report components "A" (or "A.g") and "B" of indicator values. This argument is effective only if `multipatt` function was executed using `func = "IndVal"` or `func = "IndVal.g"`.
- **...**: Additional arguments of the `summary` function.

### Details

The summary function for `multipatt` objects presents the results of the analysis by grouping species following their associated site group combination. Only significantly associated species are listed for each combination. The user can limit the species shown by setting a significance level and the minimum value for the strength of the association.
wetland

Author(s)
Miquel De Cáceres Ainsa, Biodiversity and Landscape Ecology Laboratory, Forest Science Center of Catalonia

See Also
strassoc, signassoc, multipatt

Examples

```r
library(stats)

## Loads species data
data(wetland)

## Creates three clusters using kmeans
wetkm = kmeans(wetland, centers=3)

## Runs the combination analysis using IndVal.g as statistic
wetpt = multipatt(wetland, wetkm$cluster)

## Lists those species with significant association to one combination
summary(wetpt)

## Lists those species with significant association to one combination,
## including indval components
summary(wetpt, indvalcomp=TRUE)
```

wetland

Wetland vegetation data set

Description
Vegetation of the Adelaide river alluvial plain (Australia). This data set was published by Bowman & Wilson (1987) and used in Dale (1988) to compare fuzzy classification approaches.

Usage
data(wetland)

Format
A data frame with 41 sites (rows) and 33 species (columns). Abundance values are represented in abundance classes.

Source
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