

# Package ‘paleoDiv’

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**Title** Extracting and Visualizing Paleobiodiversity

**Version** 0.4.3

**Description** Contains various tools for conveniently downloading and editing taxon-specific datasets from the Paleobiology Database <<https://paleobiodb.org>>, extracting information on abundance, temporal distribution of subtaxa and taxonomic diversity through deep time, and visualizing these data in relation to phylogeny and stratigraphy.

**License** GPL (>= 3)

**Encoding** UTF-8

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ab.gg	<i>Make a data.frame() that can be used to plot diversity data with density plots, e.g. in ggplot2</i>
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---

## Description

Make a data.frame() that can be used to plot diversity data with density plots, e.g. in ggplot2

## Usage

```
ab.gg(data, taxa = NULL, agerange = c(252, 66), precision_ma = 1)
```

## Arguments

data	list()-object containing occurrence data.frames or single occurrence data.frame()
taxa	Selection of taxa to include. If NULL, then abundance is tabulated for each unique factor level of data\$tna
agerange	Range of geological ages to include in data.frame()
precision_ma	Size of intervals (in ma) at which to calculate diversity within the age range.

## Details

Each taxon receives one entry per occurrence per time interval. The number of entries per taxon at any given point is thus proportional to the abundance of the taxon in the fossil record, and can be used for plotting with frequency- or density-based functions (e.g. `hist()`, `ggplot2::geom_violin()`, etc.). Note that using age values in the original occurrence table instead of this function will often be fully sufficient if the number of occurrences is considered an adequate proxy for abundance. However, instead using the `ab.gg()` and thus visualizing the results of the `abdistr_()` function has the benefit of the ability to account for a column of abundance values within the occurrence dataset, if available.

## Value

A `data.frame()` with two columns: `ma`, for the numerical age, and `tax`, for the taxon.

## Examples

```
data(archosauria)
ab.gg(data=archosauria, taxa=c("Ankylosauria", "Stegosauria"))->thyreophora
library(ggplot2)
ggplot(data=thyreophora, aes(x=tax, y=ma, col=tax))+ylim(252,0)+geom_violin(scale="count")
```

---

<code>abdistr_</code>	<i>Count number of entries in occurrence or collection data.frame for specific points in geological time</i>
-----------------------	--

---

## Description

Count number of entries in occurrence or collection data.frame for specific points in geological time

## Usage

```
abdistr_(
  x,
  table = NULL,
  ab.val = table$abund_value,
  ab.val.na = 1,
  smooth = 0,
  max = table$eag,
  min = table$lag,
  w = rep(1, length(x))
)
```

## Arguments

<code>x</code>	A numeric vector giving the times (in ma) at which to determine the number of overlapping records.
<code>table</code>	An occurrence or collection dataset

ab.val	Abundance value to be used. Default is table\$abund_value. If set to 1, each occurrence is treated as representing one specimen. If NULL (e.g. because this column does not exist) or NA, each occurrence is treated as the number of specimens specified under ab.val.na
ab.val.na	Value to substitute for missing entries in abundance values. Defaults to 1. Either a single numeric or a function to be applied to all non-missing entries of ab.val (e.g. mean() or median()).
smooth	The smoothing margin, in units of ma. Corresponds to the plusminus parameter of rmean(). Defaults to 0, i.e. no smoothing (beyond the resolution determined by the resolution of x)
max	Vector or column containing maximum age of each occurrence or collection
min	Vector or column containing minimum age of each occurrence or collection
w	A Vector of weights. Must be of same length as x

**Value**

A numeric vector of the same length as x, giving the estimated number of occurrence records (if ab.val==FALSE) or specimens (if ab.val==TRUE), or the estimated number of collections (if collection data are used instead of occurrences) overlapping each temporal value given in x

**Examples**

```
data(archosauria)
abdistr_(x=c(170:120), table=archosauria$Stegosauria)
```

---

add.alpha	<i>Add transparency to any color</i>
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---

**Description**

Add transparency to any color

**Usage**

```
add.alpha(col, alpha = 0.5)
```

**Arguments**

col	Color value or vector of colors
alpha	Opacity value to apply to the color(s)

**Value**

A character vector containing color hex codes.

**Examples**

```
add.alpha("red", 0.8)
```

---

ages\_archosauria      *ages\_archosauria*

---

### Description

A dataset containing earliest and latest occurrence dates for clades shown in the example phylogeny.

### Usage

```
ages_archosauria
```

### Format

A matrix with 13 rows and 2 columns containing:

**FAD** Earliest occurrence age

**LAD** Latest occurrence age

...for each taxon

---

archosauria      *archosauria*

---

### Description

A dataset of stratigraphic ranges of species within the clades in tree\_archosauria.

### Usage

```
archosauria
```

### Format

A list() object containing 2 occurrence data.frames, 1 collections data.frame and 15 species-range tables (all as data.frames) with the following data in each:

**tna** taxon names (species names)

**max** maximum ages

**min** minimum ages

**ma** mean ages

### Source

Generated from data downloaded from the paleobiology database <https://paleobiodb.org> using the functions `pdb()`, `occ.cleanup()` and `mk.sptab()`

---

<code>convert.sptab</code>	<i>Convert geological ages in taxon-range tables as constructed by <code>mk.sptab()</code> for plotting alongside a time-calibrated phylogeny.</i>
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---

### Description

Convert geological ages in taxon-range tables as constructed by `mk.sptab()` for plotting alongside a time-calibrated phylogeny.

### Usage

```
convert.sptab(sptab, tree = NULL, root.time = tree$root.time)
```

### Arguments

<code>sptab</code>	Taxon-range table to convert
<code>tree</code>	Optional phylogenetic tree to draw <code>root.time</code> from
<code>root.time</code>	Root time of the tree, used for converting ages

### Value

A `data.frame()` object in the format of the original taxon-range table, but with geological ages converted for plotting alongside the the phylogenetic tree.

### Examples

```
data(archosauria)
data(tree_archosauria)
convert.sptab(archosauria$sptab_Coelophysoidea, tree_archosauria)
```

---

<code>darken</code>	<i>Darken or lighten colors by adding/subtracting to or hsv channel values</i>
---------------------	--

---

### Description

Darken or lighten colors by adding/subtracting to or hsv channel values

### Usage

```
darken(x, add = 0, abs = NULL)
```

**Arguments**

x	Color value or vector of colors
add	Value to be added to the third hsv-channel. Can be a vector of length x, or a vector of any length if length(x)==1
abs	Value to substitute for the third hsv-channel. If set, this overrides the setting for parameter add. Can be a vector of length x, or a vector of any length if length(x)==1

**Value**

A color value or vector of color values of length x (or, if length(x)==1, the length of add or abs)

**Examples**

```
darken(ggcol(3), abs=0.5)
```

---

div.gg	<i>Make a data.frame() that can be used to plot diversity data with density plots, e.g. in ggplot2</i>
--------	--

---

**Description**

Make a data.frame() that can be used to plot diversity data with density plots, e.g. in ggplot2

**Usage**

```
div.gg(data, taxa, agerange = c(252, 66), precision_ma = 1, prefix = "sptab_")
```

**Arguments**

data	list()-object containing taxon-range tables
taxa	Selection of taxa to include
agerange	Range of geological ages to include in data.frame()
precision_ma	Size of intervals (in ma) at which to calculate diversity within the age range.
prefix	Prefix under which to find taxon-range tables in data

**Details**

Each taxon receives one entry per subtaxon (e.g. species) occurring for each time interval at which it occurs. The number of entries per taxon at any given point is thus proportional to the diversity of the taxon, and can be used to trick density functions (e.g. hist(), density()) into plotting diversity diagrams of various types. This is most useful when using ggplot2::geom\_violin(), geom\_histogram() or geom\_density() functions. A simpler alternative to achieve a similar result would be to use the taxon-range-tables directly with these functions. However, this will lead to a relative underestimate of diversity for taxa with long-lived subtaxa, since each subtaxon will only be counted once. The div.gg()-function circumvents this problem by representing each taxon for each time interval in which it occurs, i.e. the relative number of entries in the returned data.frame will be proportional to the relative number of taxa with ranges overlapping each point in time.

Value

A data.frame() with two columns: ma, for the numerical age, and tax, for the taxon.

Examples

```
data(archosauria)
div.gg(archosauria, taxa=c("Pterosauria","Aves"), agerange=c(252,0),precision_ma=1)->flyers
library(ggplot2)
ggplot(data=flyers, aes(x=tax, y=ma))+ylim(252,0)+geom_violin(scale="count")
ggplot(data=flyers, aes(col=tax, x=ma))+xlim(252,0)+geom_density(adjust=0.5)
```

---

divdistr_	<i>Calculate total species diversity for any point in time based on a taxon-range table</i>
-----------	---

---

Description

Calculate total species diversity for any point in time based on a taxon-range table

Usage

```
divdistr_(
  x,
  table = NULL,
  w = rep(1, length(x)),
  smooth = 0,
  max = table$max,
  min = table$min
)
```

Arguments

x	A point in time or vector of points in time, in ma, at which species diversity is to be determined.
table	A taxon-range table to be used, usually the output of mk.sptab()
w	A vector of weights to apply to the estimated (raw) diversity figures. This vector needs to be of the same length as x. Each raw diversity estimate will then be multiplied by the weight. Can be used to account for differences in collection intensity/sampling biases, if these can be quantified (e.g. by analyzing collection records.
smooth	The smoothing margin, in units of ma. Corresponds to the plusminus parameter of rmeans(). Defaults to 0, i.e. no smoothing (beyond the resolution determined by the resolution of x)
max	Vector or column containing the maximum age of each entry in the taxon-range table. Defaults to table\$max
min	Vector or column containing the minimum age of each entry in the taxon-range table. Defaults to table\$min



## Details

divdistr\_() produces a "maximum" estimate of taxonomic diversity at any given point in time in the fossil record. This function is based on the principle of counting the number of taxon ranges (from the provided range table) that overlap each age provided in x. As a result of uncertainty of age estimates, this may lead to an overestimation of the actual fossil diversity at each point in time, especially at the points of overlap between taxon-specific ranges. Moreover this represents a "raw", uncorrected diversity estimate that does not account for differences in sampling intensity throughout the time interval that is investigated. A rudimentary functionality for using such a correction exists in the form of the w argument, which allows the user to provide a vector of weights (of the same length as x) to be multiplied with the raw diversity estimates. Such weights can, for instance, be based on (the inverse of) the number of collections overlapping any given age in x, which can be calculated using the same basic approach as the raw diversity, by downloading collections instead of occurrence data.

## Value

A numeric vector containing taxon diversity (at the chosen taxonomic level used in the generation of the range table) at the provided ages.

## Examples

```
data(archosauria)
divdistr_(c(170:140), table=archosauria$sptab_Stegosauria)
curve(divdistr_(x, archosauria$sptab_Stegosauria), xlim=c(200, 100), ylim=c(-5, 35))
ts.stages(ylim=c(-6, -1), alpha=0.3, border=add.alpha("grey"))
ts.periods(ylim=c(-6, -1), alpha=0.0)
```

---

divdistr_int	<i>Count number of taxon records overlapping a specific time interval.</i>
--------------	--

---

## Description

Count number of taxon records overlapping a specific time interval.

## Usage

```
divdistr_int(x, table = NULL, ids = FALSE, max = table$max, min = table$min)
```

## Arguments

x	A numeric vector of length 2 specifying the start and end (in ma) of the time interval in question.
table	Taxon-range table to use
ids	Logical whether to return ids of entries in taxon-range table (defaults to FALSE) or their number
max	Vector or column containing the maximum age of each entry in the taxon-range table. Defaults to table\$max

`min` Vector or column containing the minimum age of each entry in the taxon-range table. Defaults to `table$min`

**Value**

A single numeric giving the number of entries in table overlapping the specified interval, or a numeric vector giving their indices.

**Examples**

```
data(archosauria)
divdistr_int(x=c(201,220), table=archosauria$sptab_Coelophysoidea)
```

---

<code>diversity_table</code>	<i>diversity_table</i>
------------------------------	------------------------

---

**Description**

A dataset of diversity by stage, exemplifying the output produced by the divDyn-package.

**Usage**

```
diversity_table
```

**Format**

A `data.frame()` containing mean ages and diversity figures by stage.

- x\_orig** ages for each stage in the phanerozoic
- x** ages converted for plotting on `tree_archosauria`, using the `tsconv()`-function
- Sauropodomorpha** diversity by stage for Sauropodomorpha
- etc** diversity by stage for each of the taxa represented in `tree_archosauria` ...

---

<code>ggcol</code>	<i>Replicate the standard color scheme from ggplot2</i>
--------------------	---

---

**Description**

Replicate the standard color scheme from ggplot2

**Usage**

```
ggcol(n)
```

**Arguments**

`n`                      Length of color vector to return.

**Value**

A character vector containing color hex codes.

**Examples**

```
ggcol(3)
```

---

jitterp	<i>plot data as a jitter-plot</i>
---------	-----------------------------------

---

**Description**

plot data as a jitter-plot

**Usage**

```
jitterp(x, y, width, col = "black", alpha = 0.5, ...)
```

**Arguments**

`x`                      x values to plot (if single value and y is a vector, plot is vertical)  
`y`                      y value at which to plot (if single value, plot is horizontal)  
`width`                standard deviation for jitter  
`col`                   color for points  
`alpha`                opacity for points  
`...`                other parameters to be passed on to points()

**Value**

adds the points to the open plotting device as a jitter plot and returns an invisible list()-object containing the positions of all points

**Examples**

```
c(1,2,3,2,3,2,3,4,4)->tmp
hist(tmp)
jitterp(x=tmp, y=1, width=0.1)
```

mk.sptab

*Generate a taxon-range table based on an occurrence dataset.***Description**

Generate a taxon-range table based on an occurrence dataset.

**Usage**

```
mk.sptab(
  xx = NULL,
  taxa = xx$tna,
  earliest = xx$eag,
  latest = xx$lag,
  tax = NULL
)
```

**Arguments**

xx	A data.frame() of occurrence records, containing at least the following columns: taxonomic name at level at which ranges are to be determined (e.g. species or genus), earliest possible age for each occurrence and latest possible age for each occurrence. If xx==NULL, then each column or vector must be specified individually using the following parameters
taxa	column/vector containing the taxonomic variable. Defaults to xx\$tna
earliest	column/vector containing the earliest age estimate. Defaults to xx\$eag.
latest	column/vector containing the latest age estimate. Defaults to xx\$lag.
tax	Optional. A single character string containing the taxon name, to be added as another column to the range table (useful for categorization, should several range tables be concatenated, e.g. using rbind()).

**Value**

A data.frame() containing the taxon names, the maximum and minimum age for each taxon, and (optionally) a column with the name of the higher-level taxon.

**Examples**

```
data(archosauria)
mk.sptab(archosauria$Stegosauria) -> sptab_Stegosauria
```

---

multijitter	<i>Wrapper around jitterp that plots multiple jitter plots on the same plotting device (analogous to violins())</i>
-------------	---

---

## Description

Wrapper around jitterp that plots multiple jitter plots on the same plotting device (analogous to violins())

## Usage

```
multijitter(
  x,
  data = NULL,
  group = NULL,
  horiz = FALSE,
  order = NULL,
  xlab = "",
  ylab = "",
  col = "black",
  pch = 16,
  spaces = "_",
  width = 0.1,
  xlim = NULL,
  ylim = NULL,
  add = TRUE,
  ax = FALSE,
  srt = 45,
  adj = c(1, 0),
  ...
)
```

## Arguments

x	plotting statistic (numeric vector) or formula object from which a plotting statistic and grouping variable can be extracted (i.e. of form x~group)
data	data.frame object containing x and y
group	grouping variable
horiz	logical indicating whether to plot horizontally
order	order of factor levels of categorical factor
xlab	x axis label
ylab	y axis label
col	vector of border colors
pch	vector of symbols

spaces	character string in group to replace with spaces for labels, if not NULL
width	standard deviation for jitter
xlim	x limits (data limits used if NULL)
ylim	y limits (data limits used if NULL)
add	logical whether to add to existing plot (default: TRUE)
ax	whether to plot axes
srt	angle for categorical axis text rotation
adj	adjustment for axis labels (defaults to c(1,0), i.e. top right)
...	other arguments to pass on to jitterp() and plot()

### Examples

```
data.frame(p=rnorm(50), cat=rep(c("A", "B", "B", "B", "B"), 10)) -> d
multijitter(p~cat, d, add=FALSE)
```

---

occ.cleanup	<i>Clean up occurrence dataset by removing commonly used character combinations in the identified name that will result in different factor levels for the same taxon.</i>
-------------	--

---

### Description

Clean up occurrence dataset by removing commonly used character combinations in the identified name that will result in different factor levels for the same taxon.

### Usage

```
occ.cleanup(x, remove = NULL, return.df = FALSE)
```

### Arguments

x	A occurrence data.frame or character vector containing the variable to clean up (defaults to x\$tna)
remove	Which values to remove. If NULL, a default set of commonly occurring character combinations is used ("n. gen.", "n. sp.", "cf.", "aff.", punctuation, as well as double, leading and ending spaces). If user-defined, remove needs to be formatted as a character vector with the values to be removed as names, i.e. in the format of c("remove_this" = "", "removethistoo" = "")
return.df	A logical indicating whether to return the entire data.frame (if TRUE) or just the column of taxonomic names.

### Value

A character vector containing the cleaned up taxonomic names or a dataframe with cleaned-up tna column (if return.df==TRUE).

**Examples**

```
data(archosauria)
occ.cleanup(archosauria$Stegosauria)->archosauria$Stegosauria
```

---

pdb

*Download data from the paleobiology database.*

---

**Description**

Download data from the paleobiology database.

**Usage**

```
pdb(
  taxon,
  interval = "all",
  what = "occs",
  full = FALSE,
  base = "https://paleobiodb.org/data1.2/",
  file = "list.csv",
  cc = NULL,
  envtype = NULL,
  append_additional = NULL
)
```

**Arguments**

taxon	A taxon (base_name) for which to download records.
interval	A character string indicating over which temporal interval to download data (defaults to "all"), e.g. "Phanerozoic" or "Jurassic".
what	The type of data to download (for details, see <a href="https://paleobiodb.org/data1.2/">https://paleobiodb.org/data1.2/</a> ). Defaults to "occs", which downloads occurrence data. Setting this parameter to "colls" will instead download collection data.
full	A logical indicating whether or not the full dataset is to be downloaded (defaults to FALSE). At the expense of larger file size, the full dataset contains a large number of additional columns containing data such as stratigraphy, phylogeny and (paleo)geography, which is useful for various purposes but not strictly necessary for graphing paleodiversity.
base	Character string containing base url to use. Defaults to <a href="https://paleobiodb.org/data1.2/">https://paleobiodb.org/data1.2/</a> . Entering "dev" serves as a shortcut to use <a href="https://dev.paleobiodb.org/data1.2/">https://dev.paleobiodb.org/data1.2/</a> instead (can sometimes be helpful if one of the two is unavailable).
file	Character string containing which file name to look for. Defaults to list.csv.
cc	Selection for continent (e.g. EUR for Europe, see <a href="https://paleobiodb.org">paleobiodb.org</a> documentation)
envtype	Selection for environment type (e.g. marine)
append_additional	Any additional character string to append to URL for pdb dataset

**Value**

A `data.frame()` containing the downloaded paleobioDB dataset. The column "identified\_name" will be copied into the column "tna", and (if `what==occs`) the columns "max\_ma" and "min\_ma" will be copied into the columns named "eag" and "lag" respectively, maintaining compatibility with the output of the deprecated package "paleobioDB" for those variable names.

**Examples**

```
pdb("Stegosauria")->Stegosauria
```

---

<code>pdb.autodiv</code>	<i>A wrapper around <code>pdb()</code>, <code>occ.cleanup()</code> and <code>mk.sptab()</code> to automatically download and clean occurrence data from the paleobiology database and build species-level taxon-range tables for multiple taxa in one step.</i>
--------------------------	---

---

**Description**

A wrapper around `pdb()`, `occ.cleanup()` and `mk.sptab()` to automatically download and clean occurrence data from the paleobiology database and build species-level taxon-range tables for multiple taxa in one step.

**Usage**

```
pdb.autodiv(taxa, cleanup = TRUE, interval = NULL, ...)
```

**Arguments**

<code>taxa</code>	Either a character vector of valid taxonomic names, or an object of class "phylo" whose <code>tip.labels</code> to use instead.
<code>cleanup</code>	Logical indicating whether to apply <code>occ.cleanup()</code> to occurrence data after download (defaults to TRUE)
<code>interval</code>	Stratigraphic interval for which to download data (defaults to NULL, which downloads data for all intervals)
<code>...</code>	additional arguments to be passed on to <code>pdb()</code>

**Value**

A `list()` object containing occurrence data (saved under the taxon names given) and species-level taxon-range tables (saved with the prefix "sptab\_" before the taxon names).

**Examples**

```
pdb.autodiv("Coelophysoidea")->coelo
```



---

<code>pdb.diff</code>	<i>Subtract one occurrence data.frame from another, for disentangling overlapping taxonomies or quantifying stem-lineage diversity.</i>
-----------------------	---

---

### Description

Subtract one occurrence data.frame from another, for disentangling overlapping taxonomies or quantifying stem-lineage diversity.

### Usage

```
pdb.diff(x, subtract, id_col = x$occurrence_no)
```

### Arguments

<code>x</code>	Occurrence data from which to subtract.
<code>subtract</code>	Occurrence data frame or vector of occurrence numbers to subtract from x
<code>id_col</code>	Vector or column of x containing id to be used for determining which values are also found in subtract or subtract\$occurrence_no

### Value

A data.frame() containing the difference between the two occurrence datasets, i.e. all entries that are in x but not in subtract.

### Examples

```
data(archosauria)
pdb.union(rbind(archosauria$Ankylosauria, archosauria$Stegosauria)) -> Eurypoda
pdb.diff(Eurypoda, subtract=archosauria$Stegosauria)
```

---

<code>pdb.union</code>	<i>Form the union of two occurrence data.frames or remove duplicates from occurrence data.frame. Useful if parts of a clade are not included in the downloaded dataset and need to be added separately.</i>
------------------------	---

---

### Description

Form the union of two occurrence data.frames or remove duplicates from occurrence data.frame. Useful if parts of a clade are not included in the downloaded dataset and need to be added separately.

### Usage

```
pdb.union(x, id_col = x$occurrence_no)
```

**Arguments**

<code>x</code>	Concatenated occurrence data.frames to be merged
<code>id_col</code>	Vector or column of <code>x</code> containing id to be used for determining which values contain occurrence numbers to be used for matching entries

**Value**

A data.frame() containing the first entry for each unique occurrence to be represented in `x`.

**Examples**

```
data(archosauria)
pdb.union(rbind(archosauria$Ankylosauria, archosauria$Stegosauria)) -> Eurypoda
```

---

<code>phylo.spindles</code>	<i>Plots a phylogenetic tree with spindle-diagrams, optimized for showing taxonomic diversity.</i>
-----------------------------	--

---

**Description**

Plots a phylogenetic tree with spindle-diagrams, optimized for showing taxonomic diversity.

**Usage**

```
phylo.spindles(
  phylo0,
  occ,
  stat = divdistr_,
  prefix = "sptab_",
  pos = NULL,
  ages = NULL,
  xlimits = NULL,
  ylimits = NULL,
  res = 1,
  weights = 1,
  dscale = 0.002,
  col = add.alpha("black"),
  fill = col,
  lwd = 1,
  lty = 1,
  cex.txt = 1,
  col.txt = add.alpha(col, 1),
  axis = TRUE,
  labels = TRUE,
  txt.y = 0.5,
  txt.x = NULL,
  adj.x = NULL,
```

```

    add = FALSE,
    tbmar = 0.2,
    smooth = 0,
    italicize = character()
)

```

## Arguments

phylo0	A time-calibrated phylogenetic tree to plot with spindle diagrams, or a character vector of taxonomic names for which to plot spindle diagrams.
occ	Either a list()-object containing taxon-range tables for plotting diversity, or a matrix() or data.frame()-object that contains numerical plotting statistics. If the latter is provided, the default use of divdistr_() is overridden and the function will look for a column named "x" and columns matching the phylogeny tip.labels to plot the spindles.
stat	Plotting statistic to be passed on to viol(). Defaults to use divdistr_().
prefix	Prefix for taxon-range tables in occ. Defaults to "sptab_"
pos	Position at which to draw spindles. If NULL (default), then spindles are drawn at c(1:n) where n is the number of taxa in phylo0.
ages	Optional matrix with lower and upper age limits for each spindle, formatted like the output of tree.ages() (most commonly the same calibration matrix used to time-calibrate the tree)
xlimits	Limits for plotting on the x axis.
ylimits	Limits for plotting on the y axis. If NULL (default) or not a numeric vector of length 2, the y limits are instead constructed from the tbmar parameter and the number of entries in the phylogeny or taxon list.
res	Temporal resolution of diversity estimation (if occ is a matrix or data.frame containing plotting statistics, this is ignored)
weights	Weights for diversity estimation. Must have the same length as the range of xlimits divided by res. For details, see divdistr_()
dscale	Scale value of the spindles on the y axis. Should be adjusted manually to optimize visibility of results.
col	Color to use for the border of the plotted spindles
fill	Color to use for the fill of the plotted spindles. Defaults to col.
lwd	Line width for the plotted spindles.
lty	Line type for the plotted spindles.
cex.txt	Adjustment for tip label text size
col.txt	tip label text color, defaults to be same as col, but with no transparency
axis	Logical indicating whether to plot (temporal) x axis (defaults to TRUE)
labels	Logical indicating whether to plot tip labels of phylogeny (defaults to TRUE)
txt.y	y axis alignment of tip labels

<code>txt.x</code>	x coordinates for plotting tip labels. Can be a single value applicable to all labels, or a vector of the same length as <code>phylo0\$tip.label</code> . If NULL (default), the right margin of the plot is used with right-hand alignment for the text.
<code>adj.x</code>	Numeric value giving alignment on x axis. If NULL (default) this defaults to 0 (left-aligned) but can also any other adjustment value (e.g. 0.5 for centered, 1 for right-aligned).
<code>add</code>	Logical indicating whether to add to an existing plot, in which case only the spindles are plotted on top of an existing phylogeny, or not, in which case the phylogeny is plotted along with the spindles.
<code>tbmar</code>	Top and bottom margin around the plot. Numeric of either length 1 or 2
<code>smooth</code>	Smoothing parameter to be passed on to <code>divdistr_()</code>
<code>italicize</code>	Character or numeric vector specifying which labels to italicize, if any.

## Details

The `phylo.spindles()` function allows the plotting of a phylogeny with spindle diagrams at each of its terminal branches. Various data can be represented (e.g. disparity, abundance, various diversity measures, such as those output by the `divDyn` package, etc.) depending on the settings for `occ` and `stat`, but the function is optimized to plot the results of `divdistr_()` and does so by default. If another function is used as an argument to `stat`, it has to be able to take the sequence resulting from `xlimits` and `res` as its first, and `occ` as its 'table' argument and return a vector of the same length as `range(xlimits)/res` to be plotted. If `occ` is a `list()` object containing multiple dataframes, occurrence datasets or taxon range tables are automatically converted to work with `abdistr_()` or `divdistr_()` respectively (if the plot contains a phylogeny). If `occ` is a matrix or `data.frame`, the x values must already be converted (e.g. using `tconv()`) to match the phylogeny.

## Value

A plotted phylogeny with spindle diagrams plotted at each of its terminal branches.

## Examples

```
data(archosauria)
data(tree_archosauria)
data(ages_archosauria)
data(diversity_table)
phylo.spindles(tree_archosauria, occ=archosauria, dscale=0.005, ages=ages_archosauria, txt.x=66)
phylo.spindles(tree_archosauria, occ=diversity_table, dscale=0.005, ages=ages_archosauria, txt.x=66)
```

---

`redraw.phylo`

*Redraw the lines of a phylogenetic tree.*

---

## Description

Redraw the lines of a phylogenetic tree.

**Usage**

```
redraw.phylo(
  saved_plot = NULL,
  col = "black",
  lwd = 1,
  lty = 1,
  lend = 2,
  arrow.l = 0,
  arrow.angle = 45,
  arrow.code = 2,
  indices = NULL
)
```

**Arguments**

<code>saved_plot</code>	Optional saved plot (e.g. using <code>get("last_plot.phylo", envir = ape::.PlotPhyloEnv)</code> ) to be used instead of currently active plot.
<code>col</code>	Color to be used for redrawing tree edges.
<code>lwd</code>	Line width to be used for redrawing tree edges.
<code>lty</code>	Line type to be used for redrawing tree edges.
<code>lend</code>	Style of line ends to be used for redrawing tree edges.
<code>arrow.l</code>	Length of arrow ends to be used for plotting. Defaults to 0, i.e. no visible arrow.
<code>arrow.angle</code>	Angle of arrow ends to be used for plotting. Defaults to 45 degrees.
<code>arrow.code</code>	Arrow code to be used for plotting. For details, see <code>?arrows</code>
<code>indices</code>	Optional indices which edges to redraw. Can be used to highlight specific edges in different color or style.

**Value**

Nothing (redraws selected edges of the phylogeny on the active plot device)

**Examples**

```
data(tree_archosauria)
ape::plot.phylo(tree_archosauria)
redraw.phylo(col="darkred", lwd=3, indices=c(19:24))
redraw.phylo(col="red", lwd=3, indices=c(18), arrow.l=0.1)
```

---

rmean

---

*Calculate a rolling mean for a vector x.*


---

### Description

Calculate a rolling mean for a vector x.

### Usage

```
rmean(x, width = 11)
```

### Arguments

x	Numeric vector for which to calculate the rolling mean.
width	Width of the interval over which to calculate rolling mean values. Should be an uneven number (even numbers are coerced into the next-higher uneven number)

### Value

A numeric vector of the same length as x containing the calculated rolling means, with the first and last few values being NA (depending on the setting for width)

### Examples

```
rmean(x=c(1,2,3,4,5,6),width=5)
```

---

rmeana

---

*Calculate a rolling mean based on distance within a second variable.*


---

### Description

Calculate a rolling mean based on distance within a second variable.

### Usage

```
rmeana(x0, y0, x1 = NULL, plusminus = 5, weighting = FALSE, weightdiff = 0)
```

### Arguments

x0	Numeric independent variable at which rolling mean is to be calculated.
y0	Numeric variable of which mean is to be calculated.
x1	Optional. New x values at which rolling mean of y0 is to be calculated. If x1==NULL, calculation will take place at original (x0) values.

plusminus	Criterion for the width (in x0) of the interval over which rolling mean values are to be calculated. Value represents the margin as calculated from every value of x1 or x0, i.e. for a plusminus==5, the interval over which the means are drawn will range from values with x-x_i=5 to x-x_i=-5.
weighting	Whether or not to apply weighting. If weighting==TRUE, then means are calculated as weighted means with weighting decreasing linearly towards the margins of the interval over which the mean is to be drawn.
weightdiff	Minimum weight to be added to all weights if weighting==TRUE. Defaults to 0.

### Value

A numeric vector of the same length as either x1 (if not NULL) or x0, containing the calculated rolling means.

### Examples

```
rmeans(x0=c(1,2,3,4,5,6), y0=c(2,3,3,4,5,6))
```

---

stax.sel

*Extract subsets of an occurrence data.frame.*

---

### Description

Extract subsets of an occurrence data.frame.

### Usage

```
stax.sel(taxa, rank = x$class, x = NULL)
```

### Arguments

taxa	A vector containing subtaxa (or any other entries matching entries of rank) to be returned
rank	Vector or column of x in which to look for entries matching taxa. defaults to x\$class, for selecting class-level subtaxa from large datasets (only works if pdb(...,full=TRUE))
x	Optional occurrence data.frame. If set, a data.frame with the selected entries will be returned.

### Value

If is.null(x) (default), a vector giving the indices of values matching taxa in rank. Otherwise, an occurrence data.frame() containing only the selected taxa or values.

**Examples**

```
data(archosauria)
archosauria$Stegosauria->stegos
stax.sel(c("Stegosaurus"), rank=stegos$genus,x=stegos)->Stegosaurus
```

---

synonymize

---

*Combine selected entries in a taxon-range table to remove duplicates*


---

**Description**

Combine selected entries in a taxon-range table to remove duplicates

**Usage**

```
synonymize(x, table = NULL, ids = table$tna, max = table$max, min = table$min)
```

**Arguments**

x	Indices or values (taxon names) to combine
table	Taxon-range table
ids	Vector or column of taxon names (used for matching taxon names in x). Defaults to table\$tna
max	Vector or column containing maximum ages
min	Vector or column containing minimum ages

**Details**

This function is meant as an aid to manually editing species tables and remove synonyms or incorrect spellings of taxonomic name that result in an inflated number of distinct taxa being represented.

**Value**

A data.frame containing taxon names, maximum, minimum and mean ages, with ranges for the selected entries merged and superfluous entries removed (note that the first taxon indicated by x is kept as valid).

**Examples**

```
data(archosauria)
sp<-archosauria$sptab_Stegosauria
synonymize(c(32,33),sp)->sp
synonymize(grep("stenops",sp$tna),sp)->sp
synonymize(c("Hesperosaurus mjosi","Stegosaurus mjosi"),sp)->sp
```



---

tree.age.combine	<i>Combine two calibration matrixes and fill in NA values in one with values from another</i>
------------------	---

---

## Description

Combine two calibration matrixes and fill in NA values in one with values from another

## Usage

```
tree.age.combine(ages0, ages1)
```

## Arguments

ages0	First matrix, NA values in which to replace with values from second matrix
ages1	matrix from which to take replacement values

## Details

tree.age.combine builds the union of two calibration matrices if some of the values in one of them are NAs. If exact matches for some entries cannot be found, a relaxed search matching only the first word (i.e. usually the genus name) in each taxon name is run, in order to fill in as much of the age matrix as possible with non-NA values. It is highly recommended to manually inspect the resulting table for accuracy.

## Value

A two-column matrix containing earliest and latest occurrences for each taxon in taxa, with taxon names as row names

## Examples

```
data(archosauria)
data(tree_archosauria)
tree.ages.spp(tree_archosauria, data=archosauria$sptab_Ornithopoda) -> ages_A
tree.ages.spp(tree_archosauria, data=archosauria$sptab_Allosauroidae) -> ages_B
tree.age.combine(ages_A, ages_B) -> ages
```

---

tree.ages	<i>Automatically build matrix for time-calibration of phylogenetic trees using occurrence data.</i>
-----------	---

---

## Description

Automatically build matrix for time-calibration of phylogenetic trees using occurrence data.

## Usage

```
tree.ages(phylo0 = NULL, data = NULL, taxa = NULL)
```

## Arguments

phylo0	Either an object of class phylo, or a character vector containing taxon names for building the matrix
data	Optional list()-object containing either taxon-range tables or occurrence datasets for all taxa. If NULL, data will be automatically downloaded via the pdb()-function
taxa	Deprecated argument; vector containing taxa to include in calibration matrix (can now be provided directly as phylo0)

## Details

tree.ages works best for getting occurrence dates for higher-level taxa (genus-level and up) that can be used as a base\_name in a call to the paleobiology database and will return NAs for species names (or any other taxon that cannot be found in the paleobiology database or the provided list object). For a function optimized to recover taxon ranges for genera and species, see tree.ages.spp(). It is highly recommended to manually inspect the resulting table for accuracy.

## Value

A two-column matrix containing earliest and latest occurrences for each taxon in taxa, with taxon names as row names

## Examples

```
data(archosauria)
data(tree_archosauria)
tree.ages(tree_archosauria, data=archosauria) -> ages
```

---

tree.ages.spp	<i>Automatically build matrix for time-calibration of phylogenetic trees using occurrence data.</i>
---------------	---

---

## Description

Automatically build matrix for time-calibration of phylogenetic trees using occurrence data.

## Usage

```
tree.ages.spp(phylo0, data)
```

## Arguments

phylo0	Either an object of class phylo, or a character vector containing taxon names for building the matrix
data	A higher-level taxon name to get data for in the paleobiology database, or a data.frame containing a species table containing entries for the taxa in question.

## Details

tree.ages looks for the taxon names in the tna column of a taxon-range table (as produced by mk.sptab()), so it will only recover ages for taxa that can be found there. For a function optimized for higher-level taxa that might not be represented in such a table, see tree.ages(). It is highly recommended to manually inspect the resulting table for accuracy.

## Value

A two-column matrix containing earliest and latest occurrences for each taxon in taxa, with taxon names as row names

## Examples

```
data(archosauria)
data(tree_archosauria)
tree.ages.spp(tree_archosauria, data=archosauria$sptab_Ornithopoda) -> ages
```

---

```
tree_archosauria    tree_archosauria
```

---

### Description

A time-calibrated phylogenetic tree of Archosauria.

### Usage

```
tree_archosauria
```

### Format

An object of class==phylo with 13 tips and 12 internal nodes.

---

```
ts.periods          Add a horizontal, period-level phanerozoic timescale to any plot, es-  

                   pecially calibrated phylogenies plotted with ape.
```

---

### Description

Add a horizontal, period-level phanerozoic timescale to any plot, especially calibrated phylogenies plotted with ape.

### Usage

```
ts.periods(
  phylo = NULL,
  alpha = 1,
  names = TRUE,
  exclude = c("Quarternary"),
  col.txt = NULL,
  border = NA,
  ylim = NULL,
  adj.txt = c(0.5, 0.5),
  txt.y = mean,
  bw = FALSE,
  update = NULL,
  unit = "ma"
)
```

**Arguments**

phylo	Optional (calibrated) phylogeny to which to add timescale. If phylogeny is provided, the \$root.time variable is used to convert ages so that the time scale will fit the phylogeny.
alpha	Opacity value to use for the fill of the time scale
names	Logical indicating whether to plot period names (defaults to TRUE)
exclude	Character vector listing periods for which to not plot the names, if names==TRUE
col.txt	Color(s) to use for labels.
border	Color to use for the border of the timescale
ylim	Setting for height of the timescale. Can either be one single value giving the height of the timescale, in which case the function attempts to use the lower limit of the current plot as the lower margin, or a vector of length 2 containing the lower and upper limits of the timescale.
adj.txt	Numeric vector of length==2 giving horizontal and vertical label alignment (defaults to centered, i.e. 0.5 for both values)
txt.y	Function to use to determine the vertical text position (defaults to mean, i.e. centered)
bw	Logical whether to plot in black and white (defaults to FALSE). If TRUE, time scale is drawn with a white background
update	Character string giving the filename of a .csv table for providing an updated timescale. If provided, the values for plotting the time scale are taken from the csv file instead of the internally provided values. Table must have columns named periods, bottom, top and col, giving the period names, start time in ma, end time in ma and a valid color value, respectively.
unit	what unit of time to use. Defaults to "ma" (million years), other possible settings are "ka" or 1000 (for thousands of years), or "a", 1 or "years" for years.

**Value**

Plots a timescale on the currently active plot.

**Examples**

```
data(tree_archosauria)
ape::plot.phylo(tree_archosauria)
ts.periods(tree_archosauria, alpha=0.5)
```

---

ts.stages	<i>Add a horizontal, stage-level phanerozoic timescale to any plot, especially calibrated phylogenies plotted with ape.</i>
-----------	---

---

## Description

Add a horizontal, stage-level phanerozoic timescale to any plot, especially calibrated phylogenies plotted with ape.

## Usage

```
ts.stages(
  phylo = NULL,
  alpha = 1,
  names = FALSE,
  col.txt = NULL,
  border = NA,
  ylim = NULL,
  adj.txt = c(0.5, 0.5),
  txt.y = mean,
  bw = FALSE,
  update = NULL,
  unit = "ma"
)
```

## Arguments

phylo	Optional (calibrated) phylogeny to which to add timescale. If phylogeny is provided, the \$root.time variable is used to convert ages so that the time scale will fit the phylogeny.
alpha	Opacity value to use for the fill of the time scale
names	Logical indicating whether to plot stage names (defaults to FALSE)
col.txt	Color(s) to use for labels.
border	Color to use for the border of the timescale
ylim	Setting for height of the timescale. Can either be one single value giving the height of the timescale, in which case the function attempts to use the lower limit of the current plot as the lower margin, or a vector of length 2 containing the lower and upper limits of the timescale.
adj.txt	Numeric vector of length==2 giving horizontal and vertical label alignment (defaults to centered, i.e. 0.5 for both values)
txt.y	Function to use to determine the vertical text position (defaults to mean, i.e. centered)
bw	Logical whether to plot in black and white (defaults to FALSE). If TRUE, time scale is drawn with a white background

update	Character string giving the filename of a .csv table for providing an updated timescale. If provided, the values for plotting the time scale are taken from the csv file instead of the internally provided values. Table must have columns named stage, bottom, top and col, giving the stage names, start time in ma, end time in ma and a valid color value, respectively.
unit	what unit of time to use. Defaults to "ma" (million years), other possible settings are "ka" or 1000 (for thousands of years), or "a", 1 or "years" for years.

**Value**

Plots a timescale on the currently active plot.

**Examples**

```
data(tree_archosauria)
ape::plot.phylo(tree_archosauria)
ts.stages(tree_archosauria, alpha=0.7)
ts.periods(tree_archosauria, alpha=0)
```

---

tsconv	<i>Convert geological ages for accurate plotting alongside a calibrated phylogeny</i>
--------	---

---

**Description**

Convert geological ages for accurate plotting alongside a calibrated phylogeny

**Usage**

```
tsconv(x, phylo0 = NULL, root.time = phylo0$root.time)
```

**Arguments**

x	A vector of geological ages to be converted.
phylo0	Phylogeny from which to take root.age
root.time	Numeric root age, if not taken from a phylogeny

**Value**

A numeric() containing the converted geological ages

**Examples**

```
tsconv(c(252,201,66), root.time=300)
```

viol

*Generate a violin plot***Description**

Generate a violin plot

**Usage**

```
viol(
  x,
  pos = 0,
  x2 = NULL,
  stat = density,
  dscale = 1,
  cutoff = range(x),
  horiz = TRUE,
  add = TRUE,
  lim = cutoff,
  xlab = "",
  ylab = "",
  fill = "grey",
  col = "black",
  lwd = 1,
  lty = 1,
  na.rm = FALSE,
  ...
)
```

**Arguments**

x	Variable for which to plot violin.
pos	Position at which to place violin in the axis perpendicular to x. Defaults to 0
x2	Optional variable to override the use of x as input variable for the plotting statistic. If x2 is set, the function (default: density()) used to calculate the plotting statistic is run on x2 instead of x, but the results are plotted at the corresponding values of x.
stat	The plotting statistic. Details to the density() function, as in a standard violin plot, but can be overridden with another function that can take x or x2 as its first argument. Stat can also be a numeric vector of the same length as x, in which case the values in this vectors are used instead of the function output and plotted against x as an independent variable.
dscale	The scale to apply to the values for density (or another plotting statistic). Defaults to 1, but adjustment may be needed depending on the scale of the plot the violin is to be added to.



<code>cutoff</code>	Setting for cropping the violin. Can be either a single value, in which case the input is interpreted as number of standard deviations from the mean, or a numeric vector of length 2, giving the lower and upper cutoff value directly.
<code>horiz</code>	Logical indicating whether to plot horizontally (defaults to TRUE) or vertically
<code>add</code>	Logical indicating whether to add to an existing plot (defaults to TRUE) or generate a new plot.
<code>lim</code>	Limits (in the dimensions of x) used for plotting, if <code>add==FALSE</code> . Defaults to <code>cutoff</code> , but can be manually set as a numeric vector of length 2, giving the lower and upper limits of the plot.
<code>xlab</code>	x axis label
<code>ylab</code>	y axis label
<code>fill</code>	Fill color for the plotted violin
<code>col</code>	Line color for the plotted violin
<code>lwd</code>	Line width for the plotted violin
<code>lty</code>	Line width for the plotted violin
<code>na.rm</code>	logical indicating whether to remove NA values from input data.
<code>...</code>	Other arguments to be passed on to function in parameter <code>stat</code>

### Details

Viol provides a versatile function for generating violin plots and adding them to r base graphics. The default plotting statistic is `density()`, resulting in the standard violin plot. However, density can be overridden by entering any function that can take x or x2 as its first argument, or any numeric vector containing the data to be plotted, as long as this vector is the same length as x.

### Value

A violin plot and a data.frame containing the original and modified plotting statistic and independent variable against which it is plotted.

### Examples

```
viol(x=c(1,2,2,2,3,4,4,3,2,2,3,3,4,5,3,3,2,2,1,6,7,6,9),pos=1, add=FALSE)
viol(c(1:10), width=9, stat=rmean, pos=0, add=FALSE)
viol(c(1:10), stat=c(11:20), pos=0, add=FALSE)
```

---

violins

*Wrapper around viol() to conveniently plot multiple violins on a single plot, analogous to the behavior of boxplot()*

---

### Description

Wrapper around `viol()` to conveniently plot multiple violins on a single plot, analogous to the behavior of `boxplot()`

**Usage**

```

violins(
  x,
  data = NULL,
  group = NULL,
  horiz = FALSE,
  order = NULL,
  xlab = "",
  ylab = "",
  col = "black",
  fill = "grey",
  lwd = 1,
  lty = 1,
  dscale = 1,
  xlim = NULL,
  ylim = NULL,
  spaces = "_",
  add = FALSE,
  ax = TRUE,
  srt = 45,
  adj = c(1, 0),
  na.rm = TRUE,
  ...
)

```

**Arguments**

<code>x</code>	plotting statistic (numeric vector) or formula object from which a plotting statistic and grouping variable can be extracted (i.e. of form <code>x~group</code> )
<code>data</code>	data.frame object containing <code>x</code> and <code>y</code>
<code>group</code>	grouping variable
<code>horiz</code>	logical indicating whether to plot horizontally
<code>order</code>	order of factor levels of categorical factor
<code>xlab</code>	x axis label
<code>ylab</code>	y axis label
<code>col</code>	vector of border colors
<code>fill</code>	vector of fill colors
<code>lwd</code>	vector of line widths
<code>lty</code>	vector of line types
<code>dscale</code>	density scaling factors (numeric) to apply to individual violins
<code>xlim</code>	x limits (data limits used if NULL)
<code>ylim</code>	y limits (data limits used if NULL)
<code>spaces</code>	character string in group to replace with spaces for labels, if not NULL
<code>add</code>	logical whether to add to existing plot (default: FALSE)

<code>ax</code>	whether to plot axes
<code>srt</code>	angle for categorical axis text rotation
<code>adj</code>	adjustment for axis labels (defaults to <code>c(1,0)</code> , i.e. top right)
<code>na.rm</code>	logical indicating whether to tell <code>viol()</code> to remove NA values (defaults to <code>TRUE</code> )
<code>...</code>	other arguments to pass on to <code>paleoDiv::viol()</code> and <code>plot()</code>

**Examples**

```
data.frame(p=rnorm(50), cat=rep(c("A", "B", "B", "B", "B"), 10)) -> d
violins(p~cat, d)
```

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