

Package ‘primer’

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Author M Henry H Stevens

Maintainer Hank Stevens <HStevens@muohio.edu>

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 primer-package

Functions and data for "A Primer of Ecology with R"

Description

Functions are primarily functions for systems of ordinary differential equations, difference equations, and eigenanalysis and projection of demographic matrices; data are for examples.

Details

Package: primer
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Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Stevens, M.H.H. (2009) *A Primer of Ecology with R* Springer.

See Also

[levins](#), [lvcompg](#), [predpreyLV](#), [scheffer](#), [ode](#)

BSsucc

Secondary succession data

Description

Functional group abundances (herbaceous annual, herbaceous perennial, woody) from one of the fields in the Buell-Small long term succession study (<http://www.ecostudies.org/bss/>). Data are based on visual estimates of percent cover, using annual means of each species, which are then summed for each functional group.

Usage

```
data(BSsucc)
```

Format

A data frame with 147 observations on the following 3 variables.

AGE a numeric vector; indicates the age of succession since abandonment from agriculture.

variable plant functional type; a factor with levels Annual, Perennial, Woody

value a numeric vector

Source

Data graciously provided by Scott Meiners (Eastern Illinois University, <http://www.ecostudies.org/bss/>).

References

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

Examples

```

data(BSsucc)
library(lattice)
print(xyplot(value~ AGE, groups=variable, data=BSsucc,
            type='smooth', span=.3, ylab="Percent Cover",
            xlab="Age Since Abandonment (y)",
            auto.key=list(columns=3, space="top", lines=TRUE, points=FALSE)))

```

CandG

Data drawn approximately from Collins and Glenn (1991)

Description

Numbers of species which were observed in 1–19 sites.

Usage

```
data(CandG)
```

Format

The format is: num [1:19] 32 16 10 9 8 7 8 6 4 5 ...

Source

Data are approximations of histogram values for a single year of data in:

Collins, S.L. and Glenn, S.M. (1991) Importance of spatial and temporal dynamics in species regional abundance and distribution. *Ecology*, **72**, 654–664.

References

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

Examples

```

data(CandG)
barplot(CandG, names=1:19)

```

chesson *Two-species model of the storage effect*

Description

Simulates a fluctuating environment over time, and two species' responses to the environment, after Chesson (1994).

Usage

```
chesson(alpha=c(1.1*1e-5, 1e-5), d=.1, years=10, N0=c(1e3,1e5),
        w=c(.6, 1), env.var=1, specialization=1,
        spread=0.67, type=1)
```

Arguments

alpha	a vector of length 2; the negative effects of all individuals (of both species) on each population – typically different among species.
d	disturbance rate; the proportion of all individuals killed at each time step.
years	numbers of time steps
N0	vector of length 2; initial abundances.
w	vector of length 2; average fitnesses for each species.
env.var	degree of environmental variability.
specialization	determines the narrowness of each species fitness response.
spread	determines how far apart the peak fitness responses are.
type	determines the form of C , the negative effect of competition.

Details

The argument `type` controls the value of e^C , the effect of competition on reproduction, where the annual finite rate of increase is $R = e^{E-C}$. `type = 1` causes $e^C = \alpha_i N_{J,i}$, that is, a species-specific fixed fraction of juveniles that depends on each species response to competition. This is illustrated in a for-loop in Stevens (2009, *Ch. 9, Storage Effect, Simulating Dynamics*). Any other value for `type` results in the same negative effect on both species that depends on the number of juveniles and the disturbance rate.

Value

Returns a list of length one, for use with `ode` in the `deSolve` package.

Component 1 vector of the state variables, y .

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Chesson, P.L. (1994) Multispecies competition in variable environments. *Theoretical Population Biology*, **45**, 227–276.

Stevens. M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[succniche](#)

Examples

```
out <- chession(years=50)
layout(matrix(1:4, nc=2))
matplot(out[["time"]], out[["Ns"]], type='l', lty=c(1:3),
        xlab="Time", ylab="N", log="y")
plot(out[["time"]][-1], out[["env"]], type='l',
     xlab="Time", ylab="Environment")
matplot(out[["env"]], out[["Es"]], xlab="Environment",
        ylab="Density-independent reproduction")
matplot(out[["env"]], out[["Rs"]], xlab="Environment",
        ylab="Annual growth rate")
```

clogistic

Continuous Logistic Growth

Description

A function for continuous logistic growth, for use with ode in the deSolve package.

Usage

```
clogistic(times, y, parms)
```

Arguments

times	Times points that will return N
y	N
parms	a vector of logistic growth parameters

Details

The user does not put these directly into this function, but rather uses ode in the deSolve package.

The function is based on the logistic growth equation

$$\frac{dN}{dt} = rN(1 - \alpha N)$$

or equivalently

$$\frac{dN}{dt} = rN \left(\frac{K - N}{K} \right)$$

Value

Returns of list of one component (required by ode).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Lotka, A.J. (1956) *Elements of Mathematical Biology*. Dover Publications, Inc.
Stevens. M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[dlogistic](#), [thetalogistic](#), [levins](#), [lvcomp2](#), [lvcompg](#)

Examples

```
library(deSolve)
p <- c(1, .01)
time <- 1:10
initialN <- 10
out <- ode(y=initialN, times=time,
          func=clogistic, parms=p)
plot(time, out[,-1], type='l')
```

ClostExp

Closterium Population Data

Description

Data set from an experiment testing whether trophic heterogeneity influences long term population sizes.

Usage

```
data(ClostExp)
```

Format

A data frame with 144 observations on the following 5 variables.

Nutrients a factor with levels high low

No.per.ml a numeric vector

Day a numeric vector

rep a factor with levels a b c d

ID an ordered factor with levels a.low < d.low < c.low < b.low < c.high < a.high < d.high < b.high

Source

Stevens, M. H. H. and Steiner, C. E. (2006) Effects of predation and nutrient enrichment on a food web with edible and inedible prey. *Freshwater Biology*, **51**, 666–671.

References

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

Examples

```
data(ClostExp)
library(lattice)
xyplot(log10(No.per.ml) ~ Day|Nutrients, data=ClostExp, groups=rep, type='l')
```

compcol

Two-species Competition-colonization Metapopulation Model

Description

This model implements a Levins-type metapopulation model for two species, after Hastings (1980). For use with ode in the deSolve package.

Usage

```
compcol(t, y, params)
```

Arguments

t	Argument for time
y	A vector for population 1 and 2
params	Vector or list of parameters

Value

Returns a list of length one, for use with ode in the deSolve package.

Component 1 vector of the state variables, y.

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Hastings, A. (1980) Disturbance, coexistence, history, and competition for space. *Theoretical Population Biology*, **18**, 363–373.

Stevens. M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[levins](#), [compcolM](#), [succniche](#)

Examples

```
library(deSolve)
pars <- c(c1 = .3, c2 = 1, m1 = .1, m2 = .1)
pops <- c(.1, .1)
out <- ode(y=pops, t=0:20, fun=compcol, parms = pars)
matplot(out[,1], out[,-1], type='l')
```

compcolM

Multi-species Competition-colonization Model, With Habitat Destruction

Description

Multi-species competition colonization model, with habitat destruction, after Nee and May (1992). For use with ode in the deSolve package.

Usage

```
compcolM(t, y, params)
```

Arguments

t	Argument for each time point
y	A vector for the populations
params	Vector or list of parameters

Value

Returns a list of length one, for use with ode in the deSolve package.

Component 1 vector of the state variables, y.

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Nee, S. and May, R.M. (1992) Dynamics of metapopulations: habitat destruction and competitive coexistence. *Journal of Animal Ecology*, **61**, 37–40.

Stevens. M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[levins](#), [compcol](#), [succniche](#)

Examples

```
library(deSolve)
S <- 10
ci <- 2^seq(-5, 5, length=S)
m <- rep(.1, S)
params <- list(ci=ci, m=m, S=S, D=0)
init.N <- rep(0.01, S); t=seq(1, 200, .1)
cc.out <- ode(init.N, t, compcolM, params)
matplot(t, cc.out[, -1], type="l", ylab="Proportion of Habitat", xlab="Years")
```

DemoBoot

Demographic Resampling Function

Description

This resamples three specific data sets and calculates demographic statistics and bootstrapped confidence intervals.

Usage

```
DemoBoot(stagedat = NULL, fruitdat = NULL, seeddat = NULL, n = 1)
```

Arguments

stagedat	A data frame identical in form to the data frame of the same name.
fruitdat	A data frame identical in form to the data frame of the same name.
seeddat	A data frame identical in form to the data frame of the same name.
n	Number of bootstrap replicates.

Details

This somewhat idiosyncratic function requires that the data frames have particular structures matching the data sets included in this package.

Value

Returns a list of length n , where each element is the output of a demographic analysis (see DemoInfo).

Author(s)

Hank Stevens (HStevens@muohio.edu)

References

Caswell, H. (2001) *Matrix Population Models: Construction, Analysis, and Interpretation*. Sinauer Associates, Inc., Sunderland, MA, USA, 2nd ed. edition.

Ellner, S.P. and Guckenheimer, J. (2006) *Dynamic Models in Biology*, Princeton University Press.

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

Berry, E.J., Gorchov, D.L., Endress, B.A. and Stevens, M.H.H. (2008) Source-sink dynamics within a plant population: the impact of substrate and herbivory on palm demography. *Population Ecology*, **50**, 63–77.

See Also

[DemoInfo](#), [ProjMat](#), [stagedat](#), [fruitdat](#), [seeddat](#)

Examples

```
data(stagedat); data(fruitdat); data(seeddat)
DemoBoot(stagedat = stagedat, fruitdat = fruitdat, seeddat = seeddat)
```

DemoInfo

Demographic Analyses

Description

Given a demographic projection matrix (aka transition matrix), this calculates λ , stable age/stage structure, reproductive value, sensitivity, and elasticity.

Usage

```
DemoInfo(mat)
```

Arguments

`mat` A matrix of demographic transitions (Leslie [age] or Lefkovich [stage] matrix)

Value

Returns a list with these components.

lambda	A scalar, long term asymptotic growth rate.
SSD	A vector of stable age/stage structure
RV	A vector of reproductive value
Sensitivities	A matrix of sensitivities
Elasticities	A matrix of elasticities
PPM	A population projection matrix

Author(s)

Hank Stevens (HStevens@muohio.edu)

References

- Caswell, H. (2001) *Matrix Population Models: Construction, Analysis, and Interpretation*. Sinauer Associates, Inc., Sunderland, MA, USA, 2nd ed. edition.
- Ellner, S.P. and Guckenheimer, J. (2006) *Dynamic Models in Biology*. Princeton University Press.
- Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[DemoBoot](#), [ProjMat](#)

Examples

```
### A two stage annual transition matrix
annual <- matrix( c( 0, 100, .025, 0), byrow=TRUE, nrow=2)
### Generate useful summaries
DemoInfo(annual)
```

dlogistic

Discrete Logistic Growth

Description

Lotka-Volterra single species discrete population growth.

Usage

```
dlogistic(alpha = 0.01, rd = 1, N0 = 2, t = 15)
```

Arguments

alpha	per capita negative density dependence (a positive value will result in the usual negative effect)
rd	discrete growth increment
N0	initial population size
t	end time point

Details

Of the form,

$$N_{t+1} = N_t + r_d N_t (1 - \alpha N_t)$$

Value

Returns a vector of population sizes from N_0, \dots, N_t , for integer time points.

Author(s)

Hank Stevens (HStevens@muohio.edu)

References

Stevens. M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[clogistic](#), [dlvcomp2](#), [lvcomp2](#)

Examples

```
time <- 20
Ns <- dlogistic(t=20)
plot(0:time, Ns)
```

dlvcomp2

Discrete Logistic Competition

Description

A function to simulate discrete 2 species Lotka-Volterra competition.

Usage

```
dlvcomp2(N, alpha, rd = c(1, 1))
```

Arguments

N	a vector of length two, containing N[t] for both species.
alpha	a 2 x 2 matrix of the magnitudes of the per capita (negative) effects (i.e., positive value results in a negative effect).
rd	a vector of length 2 containing the discrete growth increments for 2 species.

Value

Returns a vector of length 2, containing N[t+1] for both species.

Author(s)

Hank Stevens (HStevens@muohio.edu)

References

Stevens. M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[dlogistic](#), [lvcomp2](#), [lvcomp3](#), [lvcompg](#)

Examples

```
alphs <- matrix(c( .01, .005,
                  .008, .01), ncol=2, byrow=TRUE)
t <- 20
N <- matrix(NA, nrow=t+1, ncol=2)
N[1,] <- c(10,10)
for(i in 1:t) N[i+1,] <- dlvc2(N[i,], alphs)
matplot(0:t, N, type='l', col=1, ylim=c(0,110))
abline(h=1/alphs[1,1], lty=3)
text(0, 1/alphs[1,1], "K", adj=c(0,0))
legend("right", c(expression("Sp.1 "*(alpha[21]==0.008)),
                  expression("Sp.2 "*(alpha[12]==0.005))), lty=1:2, bty='n')
```

fruitdat

Chamaedorea Palm Fruit Data Set

Description

This data set provides the stage and number of fruits per individual in 2004.

Usage

```
data(fruitdat)
```

Format

A data frame with 68 observations on the following 2 variables. Each row corresponds to an observation of one individual in 2004.

Stage a numeric vector; the life history stage of the palm.

Y2004 a numeric vector; the number of fruits produced by an individual.

Author(s)

Hank Stevens (HStevens@muohio.edu)

Source

Berry, E.J., Gorchov, D.L., Endress, B.A., and Stevens, M.H.H. (2008) Source-sink dynamics within a plant population: the impact of substrate and herbivory on palm demography. *Population Ecology*, **50**, 63–77.

References

Stevens, M.H.H. 2009 *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[DemoBoot](#), [DemoInfo](#), [seeddat](#), [stagedat](#)

Examples

```
data(fruitdat)
with(fruitdat, table(Stage, Y2004))
```

gotelli

Propagule Rain Metapopulation Model

Description

A function for the propagule rain or mainland-island metapopulation dynamics, for use with ode in the deSolve package.

Usage

```
gotelli(t, y, parms)
```

Arguments

t	Argument for time
y	A scalar for the population variable
parms	Vector or list of parameters

Value

Returns a list of length one, for use with `ode` in the `deSolve` package.

Component 1 vector of the state variable (a scalar for the proportion of sites occupied).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Gotelli, N.J. (1991) Metapopulation models: the rescue effect, the propagule rain, and the core-satellite hypothesis. *The American Naturalist*, **138**, 768–776.

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[gotelli](#), [hanski](#), [lande](#), [MetaSim](#), [clogistic](#)

Examples

```
## The function is currently defined as
function (t, y, parms)
{
  p <- y[1]
  with(as.list(parms), {
    dp <- ce * (1 - p) - e * p
    return(list(dp))
  })
}

library(deSolve)
p <- c(ce=.1, e=.01)
time <- 1:10
initialN <- .3
out <- ode(y=initialN, times=time, func=gotelli, parms=p)
plot(time, out[,-1], type='l')
```

hanski

Core-satellite Metapopulation Model

Description

A function for the core-satellite metaapopulation dynamics, for use with `ode` in the `deSolve` package.

Usage

```
hanski(t, y, parms)
```

Arguments

t	Argument for time
y	A scalar for the population variable
parms	Vector or list of parameters

Value

Returns a list of length one, for use with `ode` in the `deSolve` package.

Component 1 vector of the state variable (a scalar for the proportion of sites occupied).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Hanski, I. (1982) Dynamics of regional distribution: the core and satellite species hypothesis. *Oikos*, **38**, 210–221.

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[gotelli](#), [hanski](#), [lande](#), [MetaSim](#), [clogistic](#)

Examples

```
prms <- c(ci<- 0.15, e=0.05)
out <- ode(y=.2, times=1:100, func=hanski, parms=prms )
matplot(out[,1], out[,2], type='l', ylab="p", xlab="time")
```

igp

A Lotka-Volterra Model of Intraguild Predation

Description

A Lotka-Volterra model of intraguild predation, after Holt and Polis (1997). For use with `ode` in the `deSolve` package.

Usage

```
igp(t, y, params)
```

Arguments

t the time point for a realization of the integration.
 y the vector of populations, at each time t.
 params a vector or list containing the necessary parameters.

Value

Returns a list of length one which is the vector of the rates of increase (required by ode).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Holt, R.D. and Polis, G.A. (1997) A theoretical framework for intraguild predation. *The American Naturalist*, **149**, 745–764.

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[lvcompg](#), [scheffer](#)

Examples

```
library(deSolve)
params <- c(bpb= 0.032, abp=10^-8, bpn=10^-5, anp=10^-4, mp=1,
           bnb=0.04, abn=10^-8, mn=1,
           r=1, abb=10^-9.5)
t=seq(0, 60, by=.1)
N.init <- c(B = 10^9, N = 10^4, P = 10^3)
igp.out <- ode(N.init, t, igp, params)
matplot(t, log10(igp.out[,-1]+1), type="l",
        ylab="log(Abundance)")
legend('right', c("B", "N", "P"), lty=1:3, col=1:3, lwd=2,
      bty="n")
```

 lande

A Metapopulation Model with Habitat Destruction

Description

A function for the metaapopulation dynamics, for use with ode in the deSolve package.

Usage

```
lande(t, y, parms)
```

Arguments

t	Argument for time
y	A scalar for the population variable
parms	Vector or list of parameters

Value

Returns a list of length one, for use with `ode` in the `deSolve` package.

Component 1 vector of the state variable (a scalar for the proportion of sites occupied).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

P. Kareiva and Wennergren, U. (1995) Connecting landscape patterns to ecosystem and population processes. *Nature*, **373**, 299–302.

Lande, R. (1987) Extinction thresholds in demographic models of territorial populations. *The American Naturalist*, **130**, 624–635.

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[gotelli](#), [hanski](#), [levins](#), [MetaSim](#), [clogistic](#)

Examples

```
## The function is currently defined as
function (t, y, parms)
{
  p <- y[1]
  with(as.list(parms), {
    dp <- ci * p * (1 - D - p) - e * p
    return(list(dp))
  })
}
library(deSolve)
p <- c(ci=.1, e=.01, D=.5)
time <- 1:10
initialN <- .3
out <- ode(y=initialN, times=time, func=lande, parms=p)
plot(time, out[,-1], type='l')
```

`levins`*Classic Metapopulation Model*

Description

A function for the classic metaapopulation dynamics, for use with `ode` in the `deSolve` package.

Usage

```
levins(t, y, parms)
```

Arguments

<code>t</code>	Argument for time
<code>y</code>	A scalar for the population variable
<code>parms</code>	Vector or list of parameters

Value

Returns a list of length one, for use with `ode` in the `deSolve` package.

Component 1 vector of the state variable (a scalar for the proportion of sites occupied).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Levins, R. (1969) Some demographic and genetic consequences of environmental heterogeneity for biological control. *Bulletin of the Entomological Society of America*, **15**, 237–240.

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[gotelli](#), [hanski](#), [lande](#), [MetaSim](#), [clogistic](#)

Examples

```
## The function is currently defined as
function (t, y, parms)
{
  p <- y[1]
  with(as.list(parms), {
    dp <- ci * p * (1 - p) - e * p
    return(list(dp))
  })
}
```

```
library(deSolve)
p <- c(ci=.1, e=.01)
time <- 1:10
initialN <- .3
out <- ode(y=initialN, times=time, func=levins, parms=p)
plot(time, out[,-1], type='l')
```

lvcomp2

Two Species Lotka-Volterra Competition

Description

System of ordinary differential equations for two species Lotka-Volterra competition. For use with ode in the deSolve package.

Usage

```
lvcomp2(t, n, parms)
```

Arguments

t	Times points that will return N.
n	a vector of length two for the population sizes at time = t.
parms	vector or list of model parameters (see details below).

Details

The parameters include r_1 , r_2 , a_{11} , a_{12} , a_{21} , a_{22} with the usual meanings. Here the a 's are the per capita effects which determine K ($a_{11} = 1/K$).

Value

Returns a list of length one which is the rate of increase (required by ode).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Lotka, A.J. (1956) *Elements of Mathematical Biology*. Dover Publications, Inc.
Stevens. M.H.H. (2009) *A Primer of Theoretical Population Ecology with R. Use R! Series*. Springer.

See Also

[lvcomp3](#), [lvcompg](#), [clogistic](#)

Examples

```
## The function is currently defined as
function (t, n, parms)
{
  with(as.list(parms), {
    dn1dt <- r1 * n[1] * (1 - a11 * n[1] - a12 * n[2])
    dn2dt <- r2 * n[2] * (1 - a22 * n[2] - a21 * n[1])
    list(c(dn1dt, dn2dt))
  })
}
library(deSolve)
parms <- c(r1 = 1, r2 = 0.1, a11 = 0.2, a21 = 0.1, a22 = 0.02, a12 = 0.01)
initialN <- c(1, 1)
out <- ode(y = initialN, times = 1:100, func = lvcomp2, parms = parms)
matplot(out[, 1], out[, -1], type = "l")
```

lvcomp3

*Three Species Lotka-Volterra Competition***Description**

System of ordinary differential equations for three species Lotka-Volterra competition. For use with ode in the deSolve package.

Usage

```
lvcomp3(t, n, parms)
```

Arguments

t the time for each integration.
n a vector of length three for the population sizes at time = t.
parms vector or list of model parameters (see details below).

Details

The parameters include r , a with the usual meanings. Here the a 's are the per capita effects which determine K ($a_{11} = 1/K_1$).

Value

Returns a list of length one which is the rate of increase (required by ode).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

- Lotka, A.J. (1956) *Elements of Mathematical Biology*. Dover Publications, Inc.
 Stevens. M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[lvcomp2](#), [lvcompg](#), [clogistic](#)

Examples

```
## The function is currently defined as
function (t, n, parms)
{
  with(as.list(parms), {
    dn1dt <- r1 * n[1] * (1 - a11 * n[1] - a12 * n[2] - a13 *
      n[3])
    dn2dt <- r2 * n[2] * (1 - a22 * n[2] - a21 * n[1] - a23 *
      n[3])
    dn3dt <- r3 * n[3] * (1 - a33 * n[3] - a31 * n[1] - a32 *
      n[2])
    list(c(dn1dt, dn2dt, dn3dt))
  })
}

library(deSolve)
parms <- c(r1 = 0.1, r2 = 0.2, r3 = 0.3,
  a11 = 0.1, a12 = 0.01, a13 = 0.01,
  a21 = 0.01, a22 = 0.15, a23 = 0.01,
  a31 = 0.01, a32 = 0.01, a33 = 0.2)
initialN <- c(1, 1, 1)
out <- ode(y = initialN, times = 1:100, func = lvcomp3, parms = parms)
matplot(out[, 1], out[, -1], type = "l")
```

 lvcompg

A General Lotka-Volterra Competition Model

Description

A general Lotka-Volterra competition model, for any number of species. For use with `ode` in the `deSolve` package. This function uses a vector and matrix within the list of parameters.

Usage

```
lvcompg(t, n, parms)
```

Arguments

t	the time point for a realization of the integration.
n	the vector of populations, at each time t.
parms	a LIST containing a vector of growth rates (r), and a matrix of interaction coefficients (a).

Value

Returns a list of length one which is the vector of the rates of increase (required by ode).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Lotka, A.J. (1956) *Elements of Mathematical Biology*. Dover Publications, Inc.
 Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[lvcomp3](#), [clogistic](#), [igp](#), [scheffer](#)

Examples

```
## Specify the number of species
S <- 10
alpha <- .01
r <- runif(S)*2
a <- matrix(rnorm(S^2, m=alpha, sd=alpha/10), nrow=S, ncol=S)
parms <- list(r,a)
t=seq(0,40, by=.1)
N0 <- runif(S)/(S*alpha)
library(deSolve)
lvout <- ode(N0, t, lvcompg, parms)
matplot(t, lvout[,-1], type="l", ylab="N", log='y')
```

Description

Originally focused on creating a community of core-satellite species, this function allows simulation of several metapopulation models, where colonization and extinction rates are stochastic draws from uniform distributions, with specified means and ranges.

Usage

```
MetaSim(Time = 50, NSims = 1, method = "hanski",
        ci = 0.25, e = 0.25, phi = 0.75, p0 = 0.5, D = 0.5)
```

Arguments

Time	A scalar for the number of time steps over which to simulate each population.
NSims	A scalar for the number of simulations, which is analogous to the number of species in the community.
method	A character string, in quotes, specifying which metapopulation model to use: "hanski", "gotelli", "lande", "levins". See "See Also" below.
ci	Scalar for mean colonization rate.
e	Scalar for mean extinction rate.
phi	A scalar for the relative variability in rates. See Details.
p0	Initial proportion of sites occupied for each species.
D	Parameter for habitat destruction; applies to only the "lande" model.

Details

phi is one half of the relative range of each rate (colonization and extinction). For each time step, each rate is drawn from a uniform distribution, $\text{Unif}(\text{rate}-\text{phi}, \text{rate}+\text{phi})$. Thus, the range is $2*\text{phi}$, and center on the specified mean (ci or e).

Value

Function returns a list with these components.

method	The method used (default is "hanski").
time	The integer sequence of times, from 0 to the value of the argument Time.
Ns	Time by NSims matrix of observed population sizes.
Parameters	A named vector of the parameters used for the simulations.

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Stevens. M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[gotelli](#), [hanski](#), [levins](#)

Examples

```
out <- MetaSim(NSims=2)
pops <- out$Ns
matplot(out$t, pops, type='l')
title(sub=paste(out$method, "model"))
```

pimmlawton

*Analysis of Jacobian Lotka-Volterra Food Web Matrices***Description**

Used primarily to repeat simulations and analyses of Pimm and Lawton (1977), given a Jacobian matrix. Analyses include eigenanalysis, but also measuring average interaction strength (May 1972), average intraspecific negative density dependence, and the strength of the omnivory interaction, if present.

Usage

```
pimmlawton(mat, N = 1, omni.i = NA, omni.j = NA, omega = NULL)
```

Arguments

mat	a numerical matrix; the "maximum" Jacobian matrix. See details below.
N	a scalar for the number of randomizations
omni.i	if omnivory is present, the row/col index for the prey.
omni.j	if omnivory is present, the row/col index for the predator.
omega	if not NULL, a scalar $0 < x < 1$ indicating the relative weight of omnivory (after McCann et al. (1998))

Details

This function simulates a constrained randomization of a Jacobian food web matrix. The matrix it uses mat is of a special form, which assumes that all non-zero values are drawn from a uniform distribution between zero and a value of some specified magnitude, either positive or negative.

Value

Returns a data frame, where each row corresponds to a single random Jacobian matrix, with the following columns.

DomEig	the real part of the dominant eigenvalue
Im	the imaginary part of the dominant eigenvalue
IntraDD	average magnitude, over all species, of the intraspecific negative density dependence; the square root of the sum of the squared diagonal elements of the random Jacobian matrix

I	average interaction strength (after May 1972); the square root of, sum of the squared off diagonal elements divided by the number of off diagonal elements.
I.omni	average interaction strength for the omnivory interaction; the square root of, sum of the squared omnivory elements effect of predator on prey and prey on predator divided by two.

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

- May, R.M. (1973) *Stability and Complexity in Model Ecosystems*, volume 6 of *Monographs in Population Biology*. Princeton University Press.
- McCann, K., Hastings, A. and Huxel, G.R. (1998) Weak trophic interactions and the balance of nature. *Nature*, **395**, 794–798.
- Pimm, S.L and Lawton, J.H. (1997) Number of trophic levels in ecological communities. *Nature*, **268**, 329–331.
- Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer. 2009.

Examples

```
### A relevant style of matrix for the first food chain in Pimm and Lawton (1977).
### Note each non-zero element is the appropriate sign, and the maximum magnitude
### specified by Pimm and Lawton (1977).

Aq = matrix(c(
  -1, -10,  0,  0,
  0.1,  0, -10,  0,
  0, 0.1,  0, -10,
  0,  0, 0.1,  0),
  nrow=4, byrow=TRUE)

pimmlawton(Aq, N=1)

out <- pimmlawton(Aq, N=2000)
out <- subset(out, -1/DomEig <150)
hist(-1/out$DomEig, main="Frequencies of Return Time")
```

Description

Resampling stochastic simulator for a single density-independent population.

Usage

```
PopSim(Rs, N0, years = 50, sims = 10)
```

Arguments

Rs	vector of observed annual growth rates ($N[t+1]/N[t]$).
N0	initial population size.
years	number of years to simulate.
sims	number of simulated populations.

Details

Designed to simulate trajectories based on resampled observed $N[t+1]/N[t]$.

Value

Returns a matrix of population sizes for time = t (rows) for each replicated population (columns).

References

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[sparrows](#)

Examples

```
lambdas <- runif(10, .5, 1.5)
out <- PopSim(Rs=lambdas, years=50, N0=50)
matplot(0:50, out, type='l')
summary(out[51,])
```

predpreyLV

The Lotka-Volterra Predator-prey Model

Description

The Lotka-Volterra predator-prey model, for use with ode in the deSolve package.

Usage

```
predpreyLV(t, y, params)
```

Arguments

t	Argument for time
y	A vector of length 2, for population 1 and 2
params	Vector or list of parameters

Value

Returns a list of length one, for use with ode in the deSolve package.

Component 1 vector of the state variables, y.

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Lotka, A.J. (1956) *Elements of Mathematical Biology*. Dover Publications, Inc.
Stevens. M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[predpreyRM](#)

Examples

```
params1 <- c(b=.5, a=.01, s=.2, e=.1)
Time <- seq(0,100, by=.1) # Set time here
LV.out <- ode(c(H0=25,P0=5), Time, predpreyLV, params1)
matplot(Time, (LV.out[,2:3]), type="l", ylab="Population Size")
```

predpreyRM

Rosenzweig-MacArthur Predator-prey Model

Description

An implementation of a predator-prey model, after Rosenzweig and MacArthur (1963). Includes prey density-dependence, and a type-II predator functional response. For use with ode in the deSolve package.

Usage

```
predpreyRM(t, y, p)
```

Arguments

t	Argument for time
y	A vector of length 2, for population 1 and 2
p	Vector or list of parameters

Value

Returns a list of length one, for use with `ode` in the `deSolve` package.

Component 1 vector of the state variables, `y`.

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Rosenzweig, M.L. and MacArthur, R.H. (1963) Graphical representation and stability conditions of predator-prey interactions. *The American Naturalist*, **97**, 209–223.

Stevens. M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[predpreyLV](#)

Examples

```
library(deSolve)
pars <- c(b = .8, e = 0.07, s = .2, w = 5, D = 400, alpha = 0.001)
Time <- 50
RM1 <- ode(c(900,120), 1:Time, predpreyRM, pars)
matplot(1:Time, RM1[,-1], type='l')
```

ProjMat

Palm Data Resampling

Description

A function to create a projection matrix from the *Chamaedorea* palm data sets. Specific to the forms of these data sets.

Usage

```
ProjMat(stagedat, fruitdat, seeddat)
```

Arguments

stagedat	Data on the vegetative stage of individuals through time; see stagedat .
fruitdat	Data on fruit production of individuals; see fruitdat .
seeddat	Data on seed fates; see seeddat .

Value

Returns a 5 x 5 projection matrix based on palm data.

References

- Caswell, H. (2001) *Matrix Population Models: Construction, Analysis, and Interpretation*. Sinauer Associates, Inc., Sunderland, MA, USA, 2nd ed.
- Ellner, S.P. and Guckenheimer, J. (2006) *Dynamic Models in Biology*. Princeton University Press.
- Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.
- Berry, E.J., Gorchoff, D.L., Endress, B.A., and Stevens, M.H.H. (2008) Source-sink dynamics within a plant population: the impact of substrate and herbivory on palm demography. *Population Ecology*, **50**, 63–77.

See Also

[DemoInfo](#), [DemoBoot](#), [stagedat](#), [fruitdat](#), [seeddat](#),

Examples

```
data(stagedat); data(fruitdat); data(seeddat)
ProjMat(stagedat, fruitdat, seeddat)
```

ross

Weekly deaths from bubonic plague in Bombay in 1905–06

Description

Kermack and McCormick (1927) provided data on the number of plague deaths per week in Bombay in 1905–06 (Bombay is the former name for the Indian coastal city Mumbai. It is the capital of Maharashtra and is one of the largest cities in the world).

Usage

```
data(ross)
```

Format

A data frame with 32 observations on the following 2 variables.

Week a numeric vector

CumulativeDeaths a numeric vector

Source

Data provided kindly by S.P. Ellner (Cornell University)

References

Kermack, W.O. and McCormick, W.G. (1927) A contribution to the mathematical theory of epidemics. *Proceedings of the Royal Society, Series A*, **115**, 700–721.

Examples

```
data(ross)
str(ross) ; plot(CumulativeDeaths ~ Week, data=ross, type='b')
```

scheffer

A resource-based model of alternative stable states

Description

A model of floating vs. submerged plant dominance in shallow aquatic systems, after Scheffer *et al.* (2003). For use with `ode` in the `deSolve` package. Floating plants are better competitors for light, as long as submerged plants cannot drive down nitrogen levels.

Usage

```
scheffer(t, y, p)
```

Arguments

t	the time point for a realization of the integration.
y	the vector of populations, at each time t.
p	a vector or list containing the necessary parameters.

Value

Returns a list of length one which is the vector of the rates of increase (required by `ode`).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Scheffer, M., Szabo, S., Gragnani, A., van Nes, E.H., Rinaldi, S., Kautsky, N., Norberg, J., Roijackers, R.M.M. and Franken, R.J.M. (2003) Floating plant dominance as a stable state. *Proceeding of the National Academy of Sciences, U.S.A.*, **100**, 4040–4045.

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[lvcomp](#), [igp](#)

Examples

```
p <- c(N=2.5, as=0.01, af=0.01, b=0.02, qs=0.075, qf=0.005,
      hs=0, hf=0.2, ls=0.05, lf=0.05, rs=0.5, rf=0.5, W=0)
t <- 1:200
Initial <- c(F=10, S=10)
S.out1 <- ode(Initial, t, scheffer, p)
matplot(t, S.out1[,-1], type='l')
legend('right', c("F", "S"), lty=1:2, col=1:2, bty='n')
```

seeddat

Chamaedorea Palm Seed Data Set

Description

This data set provides the number of seeds per individual in 2004. These data are the fates of each seed in a sample of 400 seeds. Seeds may have germinated (2), remained viable (1), or died (0).

Usage

```
data(seeddat)
```

Format

A data frame with 400 observations on the following variable.

Y2004 a numeric vector

Author(s)

Hank Stevens (HStevens@muohio.edu)

Source

Berry, E.J., Gorchov, D.L., Endress, B.A., and Stevens, M.H.H. (2008) Source-sink dynamics within a plant population: the impact of substrate and herbivory on palm demography. *Population Ecology*, **50**, 63–77.

References

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[DemoBoot](#), [DemoInfo](#), [seeddat](#), [stagedat](#)

Examples

```
data(seeddat)
table(seeddat)
```

SIR*The S-I-R Epidemiological Disease Model*

Description

The S-I-R epidemiological disease model, for use with `ode` in the `deSolve` package.

Usage

```
SIR(t, y, p)
```

Arguments

<code>t</code>	times points for which values will be returned
<code>y</code>	the vector of disease states of hosts (S, I, R)
<code>p</code>	a vector of parameters

Details

The user does not put these directly into this function, but rather uses `ode` in the `deSolve` package.

Value

Returns of list of one component (required by `ode`).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Ellner, S.P. and Guckenheimer, J. (2006) *Dynamic Models in Biology*, Princeton University Press.

Kermack, W.O. and McCormick, W.G. (1927) A contribution to the mathematical theory of epidemics. *Proceedings of the Royal Society, Series A*, **115**, 700–721.

Stevens, M.H.H. (2009) *A Primer of Ecology with R*, Use R! Series. Springer.

See Also

[ross](#), [SIRf](#), [SIRbd](#)

Examples

```

N <- 10^3; I <- R <- 1; S <- N - I - R
parms <- c(B=.01, g=4)
months <- seq(0, 3, by=0.01)
require(deSolve)
SIR.out <- data.frame( ode(c(S,I,R), months, SIR, parms) )
matplot(months, SIR.out[,-1], type='l')
legend('right', c('R', 'I', 'S'), lty=3:1, col=3:1, bty='n')

```

SIRbd

*The S-I-R Epidemiological Disease Model with Births and Deaths***Description**

The S-I-R epidemiological disease model with births and deaths (population dynamics), for use with ode in the deSolve package. This model uses mass action transmission.

Usage

```
SIRbd(t, y, p)
```

Arguments

t	times points for which values will be returned
y	the vector of disease states of hosts (S, I, R)
p	a vector of parameters

Details

The user does not put these directly into this function, but rather uses ode in the deSolve package.

Value

Returns of list of one component (required by ode).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Ellner, S.P. and Guckenheimer, J. (2006) *Dynamic Models in Biology*, Princeton University Press.

Kermack, W.O. and McCormick, W.G. (1927) A contribution to the mathematical theory of epidemics. *Proceedings of the Royal Society, Series A*, **115**, 700–721.

Stevens, M.H.H. (2009) *A Primer of Ecology with R*, Use R! Series. Springer.

See Also

[ross](#), [SIRf](#), [SIR](#)

Examples

```
library(deSolve)
N <- 10^6; R <- 0; I <- 1; S <- N - I - R
g <- 1/(13/365); b <- 1/50;
age <- 5; R0 <- 1 + 1/(b*age)
B <- R0 * (g + b) / N
parms <- c(B = B, g = g, b = b, m=b)
years <- seq(0,30, by=.1)
SIRbd.out <- data.frame(ode(c(S=S,I=I,R=R), years, SIRbd, parms, hmax=.01))
matplot(SIRbd.out[,1], sqrt(SIRbd.out[,-1]), type='l',
        lty=1:3, ylab="sqrt(No. of Individuals)", xlab='Years')
legend('right', c('S','I','R'), lty=1:3, col=1:3, bty='n')
```

SIRf	<i>The S-I-R Epidemiological Disease Model with Frequency Dependent Transmission</i>
------	--

Description

The S-I-R epidemiological disease model with frequency dependent transmission, for use with `ode` in the `deSolve` package.

Usage

```
SIRf(t, y, p)
```

Arguments

t	times points for which values will be returned
y	the vector of disease states of hosts (S, I, R)
p	a vector of parameters

Details

The user does not put these directly into this function, but rather uses `ode` in the `deSolve` package.

Value

Returns of list of one component (required by `ode`).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

- Ellner, S.P. and Guckenheimer, J. (2006) *Dynamic Models in Biology*, Princeton University Press.
- Kermack, W.O. and McCormick, W.G. (1927) A contribution to the mathematical theory of epidemics. *Proceedings of the Royal Society, Series A*, **115**, 700–721.
- Stevens, M.H.H. (2009) *A Primer of Ecology with R*, Use R! Series. Springer.

See Also

[ross](#), [SIR](#), [SIRbd](#), [ode](#)

Examples

```
R <- 0; S <- 1000; I <- 1000; N <- S+I+R
parmsf <- c(B=1, g=1)
Months <- seq(0, 8, by=0.1)
outf <- ode(c(S,I,R), Months, SIRf, parmsf)
matplot(Months, outf[,-1], type='l', ylab="Prevalence (I/N)")
legend('right', legend=c('S','I','R'), lty=1:3, col=1:3, bty='n')
```

sparrows

Song Sparrow Data Set

Description

Song Sparrow (*Melospiza melodia*) counts in Darrrtown, OH, USA. From Sauer, J. R., J.E. Hines, and J. Fallon. 2005. The North American Breeding Bird Survey, Results and Analysis 1966–2004. Version 2005.2. USGS Patuxent Wildlife Research Center, Laurel, MD.

Usage

```
data(sparrows)
```

Format

A data frame with 36 observations on the following 3 variables.

Year a numeric vector

Count a numeric vector

ObserverNumber a numeric vector

Source

<http://www.pwrc.usgs.gov/BBS/>

References

- Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also[PopSim](#)**Examples**

```
data(sparrows)
## maybe
str(sparrows)
plot(Count ~ Year, sparrows)
```

`stagedat`*Chamaedorea Palm Vegetative Stage Data Set*

Description

These stage data provide the stage of each individual in the study. Each row is an individual, and its ID number is in column 1. Data in columns 2-4 identify its stage in years 2003-2005.

Usage

```
data(stagedat)
```

Format

A data frame with 414 observations (414 individual plants) on the following 4 variables.

`PalmNo` a numeric vector; plant ID number

`Y2003` a numeric vector; stage of individual *i* in 2003

`Y2004` a numeric vector; stage of individual *i* in 2004

`Y2005` a numeric vector; stage of individual *i* in 2005

Author(s)

Hank Stevens (HStevens@muohio.edu)

Source

Berry, E.J., Gorchov, D.L., Endress, B.A., and Stevens, M.H.H. (2008) Source-sink dynamics within a plant population: the impact of substrate and herbivory on palm demography. *Population Ecology*, **50**, 63–77.

References

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[DemoBoot](#), [DemoInfo](#), [seeddat](#), [fruitdat](#)

Examples

```
data(stagedat)
table(stagedat$Y2004)
```

succniche

A Four-state model of Successional Dynamics

Description

This is the five-state, two-species model of the succession-niche model, after Pacala and Rees (1998). For use with `ode` in the `deSolve` package.

Usage

```
succniche(t, y, params)
```

Arguments

<code>t</code>	Argument for the time point at integration
<code>y</code>	A vector of length four, for states, E, M, S, and R.
<code>params</code>	Vector or list of parameters

Value

Returns a list of length one, for use with `ode` in the `deSolve` package.

Component 1 vector of the state variable (a scalar for the proportion of sites occupied).

Author(s)

Hank Stevens <HStevens@muohio.edu>

References

Pacala, S.W. and Rees, M. (1998) Models suggesting field experiments to test two hypotheses explaining successional diversity. *The American Naturalist*, **152**, 729–737.

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[levins](#), [compcol](#), [compcolM](#)

Examples

```

params.suc <- c(a=7, c=0.2, g=.1, m=0.04, D=0)
t=seq(0,50,.1)
init.suc <- c(S=0, E=0.5, M=0.5, R=0.00) # Free space is implicit, F=1-(S+E+M+R).
ccg.out <- data.frame(ode(init.suc, t, succniche, params.suc))
matplot(t, ccg.out[,-1], type="l", ylab="Relative Frequency",
        xlab="Time", ylim=c(0,1) )
legend("right", colnames(ccg.out)[5:2], lty=4:1, bty="n")

```

thetalogistic

*Continuous Theta-Logistic Growth***Description**

A function for continuous theta-logistic growth, for use with ode in the deSolve package.

Usage

```
thetalogistic(times, y, parms)
```

Arguments

times	Times points that will return N
y	N
parms	a vector of logistic growth parameters

Details

The user does not put these directly into this function, but rather uses ode in the deSolve package. See ode in the deSolve package.

Value

Returns of list of one component (required by ode).

Author(s)

Hank Stevens (HStevens@muohio.edu)

References

Sibly, R.M., Barker, D., Denham, M.C., Hone, J., and Pagel, M. (2005) On the regulation of populations of mammals, birds, fish, and insects. *Science*, **309**, 607–610.

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

See Also

[clogistic](#)

Examples

```
library(deSolve)
p <- c(r=1,alpha=.01, theta=.5)
time <- seq(1,10, by=.1)
initialN <- 10
out <- ode(y=initialN, times=time, func=thetalogistic, parms=p)
plot(time, out[,-1], type='l')
```

weeds

*Percent cover of six perennial herbaceous plants***Description**

Percent cover of six of the most common herbaceous perennial species from the Buell-Small long term succession study (<http://www.ecostudies.org/bss/>). Data are plot-level visual estimates of percent cover.

Usage

```
data(weeds)
```

Format

A data frame with 15140 observations on the following 8 variables.

X a numeric vector

Genus a factor with levels Aster, Euthamia, Solidago

Epithet a factor with levels canadensis, gigantea, graminifolia, novae-angliae, pilosus, rugosa

FieldName a factor with levels C3, C4, C5, C6, C7, D1, D2, D3, E1, E2

Age a numeric vector indicating the number of years of succession, since abandonment from agriculture.

PlotId a numeric vector

Cover a numeric vector; percent cover, estimated visually.

Species a factor with levels A.novae-angliae, A.pilosus, E.graminifolia, S.canadensis, S.gigantea, S.rugosa

Source

Data graciously provided by Scott Meiners (Eastern Illinois University, <http://www.ecostudies.org/bss/>).

References

Stevens, M.H.H. (2009) *A Primer of Ecology with R*. Use R! Series. Springer.

Examples

```
data(weeds)
str(weeds);
library(lattice)
xyplot(Cover ~ Age, data=weeds, groups=Species, type=c("a"),
auto.key=list(lines=TRUE, points=FALSE, columns=3),
ylim=c(-1,20))
```

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