

Package ‘dynamAedes’

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Title A Unified Mechanistic Model for the Population Dynamics of
Invasive Aedes Mosquitoes

Depends R (>= 4.0.0)

Imports abind, doParallel, drc, foreach, geosphere, methods, parallel,
terra

BugReports <https://github.com/mattmar/dynamAedes>

Description Generalised model for population dynamics of invasive Aedes mosquitoes. Ratio-
nale and model structure are de-
scribed here: Da Re et al. (2021) <[doi:10.1016/j.ecoinf.2020.101180](https://doi.org/10.1016/j.ecoinf.2020.101180)> and Da Re et al. (2022) <[doi:10.1101/2021.12.21.473](https://doi.org/10.1101/2021.12.21.473)>

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lubridate, stringr

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URL <https://mattmar.github.io/dynamAedes/>

NeedsCompilation no

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adci	<i>Summaries of mosquito abundance</i>
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Description

Summaries of mosquito abundance at each life stage and sub-stage for each day.

Usage

```
adci(  
  input_sim = NULL,  
  stage = NULL,  
  sub_stage = NULL,  
  breaks = c(0.25, 0.5, 0.75),  
  eval_date = NULL,  
  n.clusters = 1,  
  type = "N"  
)
```

Arguments

input_sim	matrix. dynamAedes compressed or uncompressed output matrix.
stage	character. "Eggs", "Juveniles", "Adults", or "DiapauseEggs" or any shorter attempt longer than 3 letters.
sub_stage	character. For uncompressed outputs only, defines the substage of interest. Please see cheat-sheet table.
breaks	numeric vector. Quantile breaks, default the first, the second and the third quartile: c(0.25,0.5,0.75).
eval_date	positive integer. Define the day to evaluate from the first day of introduction. Note that this can be particularly demanding in the case of spatial outputs.

n.clusters	integer. Number of parallel processes.
type	character. The type of output. Set "O" to force overall time-only summary over spatial. Default is "N" (normal).

Value

Returns a data frame or a raster with the summary of mosquito abundance at each life stage for each day.

Author(s)

Matteo Marcantonio <marcantoniomatteo@gmail.com>, Daniele Da Re <dare.daniele@gmail.com>

AedeslifeHistoryList *Reference list for **Aedes** stages and substages*

Description

Reference files to match simulation output matrices with **Aedes** stages and substages as modelled in dynamAedes. The list contains:

Usage

```
data(AedeslifeHistoryList)
```

Format

A list of two matrices

Details

- speciesheet: description of each substage for each species
- codesheet: reference coding to match substages to simulation output

dici	<i>Estimate of of mosquito dispersal</i>
------	--

Description

Estimates of dispersal (in km²) for the simulated mosquito population when scale = "1c".

Usage

```
dici(
  input_sim = NULL,
  eval_date = NULL,
  breaks = c(0.25, 0.5, 0.75),
  space = FALSE
)
```

Arguments

input_sim	matrix. dynamAedes.m compressed output matrix (compressed=TRUE).
eval_date	numeric. Define the day of evaluation; it refers to the column number of the input temperature matrix.
breaks	numeric vector. Quantile breaks, default interquartile range: c(0.25, 0.5, 0.75).
space	See below for more details.

Value

if space=FALSE then it returns a dataframe with quantiles of the distribution of dispersal distances;
if space=TRUE (experimental) then it returns the invaded cells on the last day of model simulations for each of the iterations.

Author(s)

Matteo Marcantonio <marcantoniomatteo@gmail.com>, Daniele Da Re <daniele.dare@uclouvain.be>

dynamAedes.m	<i>Life cycle simulation of Aedes mosquitoes</i>
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Description

Function to simulate population dynamics of *Aedes* mosquitoes

Usage

```
dynamAedes.m(
  species = NULL,
  intro.eggs = 0,
  intro.deggs = 0,
  intro.adults = 0,
  intro.juveniles = 0,
  scale = NULL,
  intro.cells = NULL,
  jhvw = NULL,
  temps.matrix = NULL,
  startd = 1,
  endd = NA,
  cells.coords = NULL,
  coords.proj4 = NA,
  lat = NA,
  long = NA,
  road.dist.matrix = NULL,
  avgpdisp = NA,
  pDispersal = TRUE,
  iter = 1,
  n.clusters = 1,
  cluster.type = "PSOCK",
  compressed.output = TRUE,
  suffix = NA,
  cellsize = 250,
  maxadisp = 600,
  dispbins = 10,
  verbose = 0,
  seeding = FALSE
)
```

Arguments

species	character. Select what species to model: "aegypti", "albopictus", "japonicus", "koreicus". Default species = "aegypti".
intro.eggs	positive integer. number of introduced eggs, default intro.eggs = 0.
intro.deggs	positive integer. number of introduced diapause eggs, default intro.deggs = 100.
intro.adults	positive integer. number of introduced adults, default intro.adults = 0.
intro.juveniles	positive integer. number of introduced juveniles, default intro.juveniles = 0.
scale	character. Define the model spatial scale: punctual/weather station "ws", local "lc", or regional "rg". Active and passive dispersal is enabled only for scale = "lc". Default scale = "ws".
intro.cells	positive integer. One or more cells (id) where to introduce the population at local ("lc") scale. If intro.cells=NULL, then a random cell is used for introduction; If

	intro.cells is a vector of cell ids then a cell is drawn at random from the vector (with repetition) for introduction in each model iteration.
jhwv	positive integer. Juvenile-habitat water volume, define the volume (L) of water habitat presents in each spatial unit (parametrised with data retrieved from doi:10.1111/13652664.12620). Default jhwv = 1.
temps.matrix	matrix. A matrix of daily (average) temperatures (in degrees Celsius degree x 1000) used to fit the life cycle rates. This matrix must be organised with the daily temperature observations as columns and the geographic position of the i-grid cell as rows. Importantly , the first column must match startd date.
startd	Character date (ISO format "%Y-%m-%d"). Date of start of simulations.
endd	Character date (ISO format "%Y-%m-%d"). Date of end of simulation. It can be NA; then it will be derived using the number of columns in temps.matrix.
cells.coords	matrix. A matrix reporting the spatial coordinates of the temperature observations.
coords.proj4	string. Proj4 string of cell coordinates used for the calculation of photoperiod.
lat	numeric. Latitude value of the area of interested used to derive the photoperiod (and thus the diapause eggs allocation function).
long	numeric. Longitude value of the area of interested used to derive the photoperiod (and thus the diapause eggs allocation function)
road.dist.matrix	matrix. when scale = "lc", defines the matrix containing the distances (in meters) between grid cells intersecting the road network for the mosquito passive dispersal process. colnames(road.dist.matrix) must correspond to the same cell in temps.matrix (may be an issue if the coordinates used for creating road.dist.matrix have been subset to match road segments).
avgpdisp	optional. when scale = "lc", define the average car trip distance (in meters) for the mosquito passive dispersal process. The value can be set by the users (positive numeric), or the estimates made by Pasaoglu et al. 2012) for the following European countries: France "fra", Germany "deu", Italy "ita", Poland "pol", Spain "esp" and the United Kingdom "uk". The average passive dispersal distance must be smaller than the maximum distance in road.dist.matrix .
pDispersal	boolean. if TRUE (default) then the model considers passive dispersal.
iter	positive integer. Define the number of model iterations.
n.clusters	positive integer. Defines the number of parallel processes.
cluster.type	character. Defines the type of cluster, default "PSOCK".
compressed.output	logical. Default TRUE, if FALSE provide abundance for each model's subcompartment; if FALSE abundances are summed per compartment.
suffix	character. Model output suffix for output RDS.
cellsize	positive integer. When scale = "lc", defines the minimal distance for the active dispersal kernel and should match the spatial resolution of temps.matrix to avoid inconsistencies. Default cellsize = 250.
maxadisp	positive integer. When scale = "lc", defines the maximum daily active dispersal, default maxadisp = 600.

dispbins	positive integer. When scale = "lc", defines the resolution of the active dispersal kernel, default dispbins = 10.
verbose	integer. if 1 then an overview of population dynamics is printed in the console, if 2 more information on population dynamics are printed out. Default is 0 (silent).
seeding	logical, default FALSE, if seeding=TRUE a fixed seed is applied for result reproducibility.

Value

Matrix or a list of matrices containing, for each iteration, the number of individuals in each life stage per day (and for each grid cell of the study area if scale="lc" or "rg"). If the argument compressed.output=FALSE (default TRUE), the model returns the daily number of individuals in each life stage sub-compartment.

Author(s)

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See Also

Beta regression functions were taken from the R package aomisc, which may be available at <https://github.com/OnofriAndreaPG/aomisc>.

Examples

```
## Run dynamAedes at local scale for 5 days
# Make a toy temperature time series
w <- matrix(seq(20,25,length.out=5),ncol=5)*1000
# Run the model
simout <- dynamAedes.m(
  species="koreicus",
  scale="ws",
  intro.eggs=10,
  jhvw=2,
  temps.matrix=w,
  startd="2021-06-21",
  endd="2021-06-25",
  lat=42,
  long=8,
  n.clusters=1,
  iter=1,
  compressed.output=TRUE,
  verbose=FALSE)
```

dynamAedesClass-class *S4 class representing the output of dynamAedes.m*

Description

S4 class representing the output of dynamAedes.m

Slots

species Character. The simulated species.
 scale Character. The scale of the simulation.
 start_date Character. The introduction date.
 end_date Character. The end date of the simulation.
 n_iterations Numeric. The number of iterations.
 stage_intro Character. The introduced mosquito stage.
 n_intro Numeric. The number of propagules introduced.
 coordinates Matrix. The coordinates of each cell.
 compressed_output Logical. If output is at stage or substage level.
 jhvw Numeric. The volume of water in the system.

icci	<i>Number of invaded cells</i>
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Description

Compute a summary of the number of invaded cells over model iterations

Usage

```
icci(input_sim = NA, eval_date = NULL, breaks = c(0.25, 0.5, 0.75))
```

Arguments

input_sim	matrix. dynamAedes.m compressed output matrix (compressed=TRUE).
eval_date	numeric. Define the day of evaluation; it refers to the column number of the input temperature matrix.
breaks	numeric vector. Quantile breaks, default interquartile range: c(0.25, 0.5, 0.75).

Value

icci returns quantiles of the distribution of the invaded cell number for the specified. The output should be interpreted according to model spatial scale (i.e. scale='rg' or scale='lc' give different interpretation).

Author(s)

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max,dynamAedesClass-method

Max method for dynamAedesClass Provides the max number of days with at least one propagule in the system (any stage) along iterations.

Description

Max method for dynamAedesClass Provides the max number of days with at least one propagule in the system (any stage) along iterations.

Usage

```
## S4 method for signature 'dynamAedesClass'
max(x, na.rm = FALSE)
```

Arguments

x	An object of class dynamAedesClass.
na.rm	logic.

Value

An integer.

Examples

```
## Not run:
max(sim)

## End(Not run)
```

min,dynamAedesClass-method

Min method for dynamAedesClass Provides the min number of days with at least one propagule in the system (any stage) along iterations.

Description

Min method for dynamAedesClass Provides the min number of days with at least one propagule in the system (any stage) along iterations.

Usage

```
## S4 method for signature 'dynamAedesClass'
min(x, na.rm = FALSE)
```

Arguments

x	An object of class dynamAedesClass.
na.rm	logic.

Value

An integer.

Examples

```
## Not run:
min(sim)

## End(Not run)
```

psi

Proportion of successful introductions

Description

Compute the proportion of "successful" introductions.

Usage

```
psi(input_sim = NULL, eval_date = NULL)
```

Arguments

input_sim	matrix. dynamAedes.m compressed output matrix (compressed=TRUE).
eval_date	positive integer. define the day(s) to calculate the proportion of successful introductions which should match the column number of the temperature matrix used to inform the model.

Value

psi returns the proportion of model iterations that resulted in a viable mosquito population (defined as: iterations with at least one individual alive in any life stage) at a given date.

Author(s)

Matteo Marcantonio <marcantoniomatteo@gmail.com>, Daniele Da Re <daniele.dare@uclouvain.be>

psi_sp	<i>Probability of successful introduction (spatial)</i>
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Description

Compute the proportion of successful introductions per each cell of the grid.

Usage

```
psi_sp(input_sim = NULL, eval_date = NULL, n.clusters = 1)
```

Arguments

input_sim	matrix. dynamAedes.m compressed output matrix (compressed=TRUE).
eval_date	positive integer. Define the day(s) to calculate the proportion of successful introductions which should match the column number of the temperature matrix used to inform the model.
n.clusters	positive integer. Define the number of parallel processes.

Value

psi_sp returns a raster with the proportion of model iterations that resulted in a viable mosquito population at a given date for a given life stage in each cell of the grid.

Author(s)

Matteo Marcantonio <marcantoniomatteo@gmail.com>, Daniele Da Re <daniele.dare@uclouvain.be>

spreader	<i>Temporal downscaling of entomological surveillance observations</i>
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Description

Temporal downscaling of entomological surveillance observations

Usage

```
spreader(
  mydf = NULL,
  date.field = NULL,
  value.field = NULL,
  counter.field = NULL,
  seed = 123
)
```

Arguments

mydf	A data.frame.
date.field	character, name of field containing dates.
value.field	integer, name of field containing the number of individuals sampled.
counter.field	integer, name of the field containing the number of days/weeks between each sampling. This is optional, if NULL then the function will compute the value assuming the trap was active during the whole period between two consecutive samplings.
seed	integer, define the seed for the binomial draws, default seed = 123.

Value

Returns a data.frame with the "adjusted value", i.e. the observation spread over the period of activity of the trap

Author(s)

Daniele Da Re <dare.daniele@gmail.com>, Giovanni Marini <dare.daniele@gmail.com>

summary,dynamAedesClass-method

Summary method for dynamAedesClass Provides a summary of simulations based on the dynamAedesClass.

Description

Summary method for dynamAedesClass Provides a summary of simulations based on the dynamAedesClass.

Usage

```
## S4 method for signature 'dynamAedesClass'
summary(object)
```

Arguments

object	An object of class dynamAedesClass.
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Value

A character vector with the summary details of the simulation.

Examples

```
## Not run:  
summary(sim)  
  
## End(Not run)
```

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