

# Package ‘ThermalSampleR’

February 21, 2022

**Type** Package

**Title** Calculate Sample Sizes Required for Critical Thermal Limits Experiments

**Version** 0.1.0

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**Description** We present a range of simulations to aid researchers in determining appropriate sample sizes when performing critical thermal limits studies (e.g. CTmin/CTmin experiments). A number of wrapper functions are provided for plotting and summarising outputs from these simulations. These simulations are presented in Owen, C., Sutton, G., Martin, G., van Steenderen, C., and Coetzee, J. Sample size determination for critical thermal limits studies. 2022. Physiological Entomology. Under review. The GUI version of this package is available on the R Shiny online server at: <[https://clarkevansteenderen.shinyapps.io/ThermalSampleR\\_Shiny/](https://clarkevansteenderen.shinyapps.io/ThermalSampleR_Shiny/)>, or it is accessible via GitHub at <[https://github.com/clarkevansteenderen/ThermalSampleR\\_Shiny/](https://github.com/clarkevansteenderen/ThermalSampleR_Shiny/)>. We would like to thank Grant Duffy (University of Otago, Dundedin, New Zealand) for granting us permission to use the source code for the Test of Total Equivalency function.

**License** GPL-3

**Encoding** UTF-8

**LazyData** true

**Depends** R (>= 2.10)

**Imports** tidyrr, dplyr, purrr, rlang, MASS (>= 7.3), stats (>= 3.4.0), graphics (>= 3.4.0), base (>= 3.4.0), magrittr, utils, ggplot2, cowplot, EnvStats, sn, janitor

**RoxygenNote** 7.1.2

**Suggests** rmarkdown, knitr

**VignetteBuilder** knitr

**NeedsCompilation** no

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**Repository** CRAN

**Date/Publication** 2022-02-21 09:00:26 UTC

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boot_one	<i>Bootstrap sampling to calculate summary statistics of CTL values</i>
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### Description

Calculate mean and CI's of CTL for a single population

### Arguments

data	Data frame contains raw data. Must contain a column with a population identifier (e.g. population ID), and a column containing critical thermal limit data (e.g. temperatures at which critical limits are reached).
groups_col	Factor. Column containing name(s) of population(s) of interest
groups_which	Character. Which population should be analysed?
n_max	Numeric. Maximum sample size to extrapolate simulations.
n_min	Numeric. Minimum sample size to extrapolate simulations. Defaults to 3.
iter	Numeric. Number of bootstrap samples. Defaults to 29.
response	Numeric. Column containing thermal limit data for individual samples

### Value

A data frame of CTL summary statistics from bootstrap resamples

**Examples**

```
head(coreid_data)
sims <- boot_one(data = coreid_data,
                 groups_col = col,
                 groups_which = "Catorhintha schaffneri_APM",
                 response = response,
                 n_max = 49,
                 iter = 99)
```

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boot_two	<i>Bootstrap sampling for difference in means between two groups</i>
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**Description**

Calculate difference in mean CT limits between two groups.

**Arguments**

data	Data frame contain raw data.
groups_col	Factor. Column containing names of two populations to compare
n_max	Numeric. Maximum sample size to extrapolate simulations.
n_min	Numeric. Minimum sample size to extrapolate simulations. Defaults to 3.
iter	Numeric. Number of bootstrap samples. Defaults to 29.
response	Numeric. Column containing thermal limit data for individual samples.
group1	String. Name of first population to compare.
group2	String. Name of second population to compare.
colour_exp	Colour of the experimental data. Defaults to "blue".
colour_extrap	Colour of the extrapolated data. Defaults to "red".
legend.position	Position of the legend. Defaults to "top". Can be "bottom", "left", "right", or "none".
ggtheme	The theme for the ggplot created. See ggplot2 themes for options. Default set to theme_classic().

**Value**

A data frame of bootstrap resamples

## Examples

```
head(coreid_data)
sims <- boot_two(data = coreid_data,
                 groups_col = col,
                 response = response,
                 group1 = "Catorhintha schaffneri_APM",
                 group2 = "Catorhintha schaffneri_NPM",
                 n_max = 49,
                 iter = 99)
```

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coreid_data	<i>Example critical thermal limit data for ThermalSampleN package</i>
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## Description

A dataset containing critical thermal limit (CTmin) data for the sap-sucking bug, *Catorhintha schaffneri*.

## Usage

```
coreid_data
```

## Format

A data frame with 60 rows and 2 variables:

**col** insect population tested, string

**response** CTmin value for individual insect, in degrees celsius ...

## Source

"Unpublished data provided by Philippa Muskett (Centre for Biological Control, Rhodes University, South Africa)

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equiv_tost	<i>equiv_tost</i>
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## Description

Perform a Test of Total Equivalence as adapted from Duffy et al. (2021) (<<https://doi.org/10.1111/1365-2435.13928>>)

**Arguments**

data	Data frame contains raw data. Must contain a column with a population identifier (e.g. population ID), and a column containing critical thermal limit data (e.g. temperatures at which critical limits are reached).
groups_col	Factor. Column containing the name of the population of interest (group ID)
groups_which	Character. Which population should be analysed?
response	Numeric. Column containing thermal limit data for individual samples
skews	Numeric. Vector containing skewness parameter(s). Defaults to 0, 1, 2, 10, 50.
equiv_margin	Numeric. Equivalence of subsets to full population CT estimate (unit = degree Celcius). Defaults to 1.
pop_n	Numeric. Size of population to sample (will test subsamples of size pop_n - x against pop_n for equivalence) Defaults to population size = 30
colrs	Character. Vector of colours for each skewness parameter value. E.g. if two skewness parameter values are set, choose two colours: colrs = c("blue", "red"). Defaults to "blue", "red", "orange", "forestgreen", "lightgrey".

**Value**

Two plots; (a) equivalence of means, and (b) equivalence of variances

**Examples**

```
head(coreid_data)
res <- equiv_tost(data = coreid_data,
                 groups_col = col,
                 groups_which = "Catorhintha schaffneri_APM",
                 response = response,
                 skews = c(1,10),
                 colrs = c("lightblue", "lightpink"),
                 equiv_margin = 1,
                 pop_n = 5)
```

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plot\_one\_group

*Plot output from boot\_sample*

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**Description**

Plot output from boot\_one.

**Arguments**

x	Output from boot_one function.
n_max	Numeric. Maximum sample size to extrapolate simulations.
n_min	Numeric. Minimum sample size to extrapolate simulations. Defaults to 3.
colour_exp	Colour of the experimental data. Defaults to "blue".
colour_extrap	Colour of the extrapolated data. Defaults to "red".
legend.position	Position of the legend. Defaults to "top". Can be "bottom", "left", "right", or "none".
alpha_val	Change the degree of shading of the graphs. Default is 0.2.
ggtheme	The theme for the ggplot created. See ggplot2 themes for options. Default set to theme_classic().

**Value**

Two plots; (a) precision of the CTmin estimate across experimental and extrapolated sample sizes; (b) the sampling distribution (range of plausible CTmin values) across experimental and extrapolated sample sizes.

**Examples**

```
sims <- boot_one(coreid_data,
                 groups_col = col,
                 groups_which = "Catorhintha schaffneri_APM",
                 n_max = 30,
                 response = response)
plot_one_group(x = sims,
               n_min = 3,
               n_max = 15,
               colour_exp = "darkblue",
               colour_extrap = "green",
               legend.position = "right")
```

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plot\_two\_groups

*Plot output from boot\_two\_groups*

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**Description**

Plot output from boot\_two.

**Arguments**

x	Output from boot_two_groups function. Defaults to 'sims'.
n_max	Numeric. Maximum sample size to extrapolate simulations.
n_min	Numeric. Minimum sample size to extrapolate simulations. Defaults to 3.
colour_exp	Colour of the experimental data. Defaults to "blue".
colour_extrap	Colour of the extrapolated data. Defaults to "red".
legend.position	Position of the legend. Defaults to "top". Can be "bottom", "left", "right", or "none".
alpha_val	Change the degree of shading of the graphs. Default is 0.2.
ggtheme	The theme for the ggplot created. See ggplot2 themes for options. Default set to theme_classic().

**Value**

Two plots: (a) the precision of the estimates for the difference in CTmin between the two selected groups across sample sizes; (b) the 95

**Examples**

```
sims <- boot_two(data = coreid_data,
                 groups_col = col,
                 response = response,
                 group1 = "Catorhintha schaffneri_APM",
                 group2 = "Catorhintha schaffneri_NPM",
                 n_max = 30,
                 iter = 99)

plots <- plot_two_groups(x = sims,
                        n_min = 3,
                        n_max = 30,
                        colour_exp = "gold",
                        colour_extrap = "darkgreen",
                        legend.position = "right")
```

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