

Package ‘ecotox’

March 20, 2018

Type Package

Title Analysis of Ecotoxicology

Version 1.3.1

Description A simple approach to using a probit or logit analysis to calculate lethal concentration (LC) or time (LT) and the appropriate fiducial confidence limits desired for selected LC or LT for ecotoxicology studies (Finney 1971; Wheeler et al. 2006; Robertson et al. 2007). The simplicity of 'ecotox' comes from the syntax it implies within its functions which are similar to functions like `glm()` and `lm()`. In addition to the simplicity of the syntax, a comprehensive data frame is produced which gives the user a predicted LC or LT value for the desired level and a suite of important parameters such as fiducial confidence limits and slope.
Finney, D.J. (1971, ISBN: 052108041X);
Wheeler, M.W., Park, R.M., and Bailer, A.J. (2006) <doi:10.1897/05-320R.1>;
Robertson, J.L., Savin, N.E., Russell, R.M., and Preisler, H.K. (2007, ISBN: 0849323312).

Depends R (>= 3.3.0)

Imports ggplot2, magrittr, stats

Suggests covr, dplyr, Hmisc, tidyr, testthat, xlsx

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lampreytime	<i>Lethal time data for seasonal exposure to TFM for larval sea lamprey</i>
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Description

This dataset contains the amount of responding/dead lamprey from 1 to 12 h of exposure to the piscicide, 3-trifluoromethyl-4-nitrophenol (TFM), for the calculated LC50s at each month for the 2011 seasonal larval sea lamprey TFM toxicity data.

Usage

```
lampreytime
```

Format

A data frame containing 64 rows and 7 columns.

nominal.dose nominal TFM dose(mg/L)

dose averaged measured TFM dose (mg/L) over 12 h of exposures

month month in which toxicity test occurred

hour duration of exposure in hours

response number of lamprey that responded over 12 h exposure to TFM

survive number of lamprey that survived over 12 h exposure to TFM

total total number of lamprey that were exposed to TFM over 12 h

Details

For each month, new lamprey were collected from the deer creek, MI, and were randomly assigned to a tank for exposure to the piscicide, 3-trifluoromethyl-4-nitrophenol (TFM). The LC50 at each month was then calculated and the amount of responding/dead lamprey from 1 to 12 h was recorded.

Source

Hlina, B.L., Birceanu, O., Tessier, L.R., Robinson, C., Muhametsafina, A., Bragg, L.M, Servos, M.R., Wilkie, M.P. In Preparation. Changes in the sensitivity of piscicide in an invasive species. Environmental Science & Technology.

lampreytox	<i>Lethal concentration data for seasonal exposure to TFM for larval sea lamprey</i>
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Description

This dataset contains 2011 seasonal larval sea lamprey exposed to the piscicide, 3-trifluoromethyl-4-nitrophenol (TFM) toxicity data.

Usage

lampreytox

Format

A data frame containing 64 rows and 7 columns.

nominal.dose nominal TFM dose (mg/L)

tank tank assignment

month month in which toxicity test occurred

dose averaged measured TFM dose (mg/L) over 12 h of exposures

response number of lamprey that responded over 12 h exposure to TFM

survive number of lamprey that survived over 12 h exposure to TFM

total total number of lamprey that were exposed to TFM over 12 h

Details

For each month, new lamprey were collected from the deer creek, MI, and were randomly assigned to a tank for exposure to varying doses of the piscicide, 3-trifluoromethyl-4-nitrophenol (TFM).

Source

Hlina, B.L., Birceanu, O., Tessier, L.R., Robinson, C., Muhametsafina, A., Bragg, L.M, Servos, M.R., Wilkie, M.P. In Preparation. Changes in the sensitivity of piscicide in an invasive species. Environmental Science & Technology.

LC_logit

*Lethal Concentration Logit***Description**

Calculates lethal concentration (LC) and its fiducial confidence limits (CL) using a logit analysis according to Finney 1971, Wheeler et al. 2006, and Robertson et al. 2007.

Usage

```
LC_logit(formula, data, p = seq(1, 99, 1), weights,
         subset = NULL, het_sig = NULL, conf_level = NULL)
```

Arguments

formula	an object of class formula or one that can be coerced to that class): a symbolic description of the model to be fitted. The details of model specification are given under Details.
data	an optional data frame, list or environment (or object coercible by as.data.frame to a data frame) containing the variables in the model. If not found in data, the variables are taken from environment(formula), typically the environment from which LC_logit is called.
p	Lethal Concentration (LC) values for given p, example will return a LC50 value if p equals 50. If more than one LC value wanted specify by creating a vector.
weights	vector of 'prior weights' to be used in the fitting process. Should be a numeric vector and is required for analysis.
subset	allows for the data to be subset if desired. Default set to NULL.
het_sig	significance level from person's chi square goodness-of-fit test that is used to decide if a heterogeneity factor is used. NULL is set to 0.15.
conf_level	Adjust confidence level as necessary or NULL set at 0.95.

Value

Returns a data frame with predicted LC for given p level, lower CL (LCL), upper CL (UCL), LCL and UCL distance away from LC (LCL_dis & UCL_dis; important for creating a plot), Pearson's chi square goodness-of-fit test, slope, intercept, slope and intercept p values and standard error, and LC variance.

References

Finney, D.J., 1971. Probit Analysis, Cambridge University Press, Cambridge, England, ISBN: 052108041X

Wheeler, M.W., Park, R.M., and Bailey, A.J., 2006. Comparing median lethal concentration values using confidence interval overlap or ratio tests, Environ. Toxic. Chem. 25(5), 1441-1444.10.1897/05-320R.1

Robertson, J.L., Savin, N.E., Russell, R.M. and Preisler, H.K., 2007. Bioassays with arthropods. CRC press. ISBN: 9780849323317

Examples

```
head(lampreytox)

# within the dataframe used, control dose, unless produced a value
# during experimentation, are removed from the dataframe,
# as glm cannot handle values of infinite. Other statistical programs
# make note of the control dose but do not include within analysis

#calculate LC50 and LC99 for May

m <- LC_logit((response / total) ~ log10(dose), p = c(50, 99),
             weights = total,
             data = lampreytox,
             subset = c(month == "May"))

#view calculated LC50 and LC99 for seasonal toxicity of a piscicide,
#to lamprey in 2011

m

#dose-response curve can be plotted using 'ggplot2'

library(ggplot2)

p1 <- ggplot(data = lampreytox[c(1:19), ],
            aes(x = log10(dose), y = (response / total))) +
  geom_point() +
  geom_smooth(method = "glm",
             method.args = list(family = binomial(link = "logit")),
             aes(weight = total), colour = "#FF0000", se = TRUE)

p1

#calculate LC50s and LC99s for multiple toxicity tests, June, August, and September

j <- LC_logit((response / total) ~ log10(dose), p = c(50, 99),
             weights = total,
             data = lampreytox,
             subset = c(month == "June"))

a <- LC_logit((response / total) ~ log10(dose), p = c(50, 99),
             weights = total,
             data = lampreytox,
             subset = c(month == "August"))

s <- LC_logit((response / total) ~ log10(dose), p = c(50, 99),
             weights = total,
             data = lampreytox,
```

```

subset = c(month == "September"))

#group results together in a dataframe to plot with 'ggplot2'

results <- rbind(m[, c(1, 3:8, 11)], j[,c(1, 3:8, 11)],
                a[, c(1, 3:8, 11)], s[, c(1, 3:8, 11)])

results$month <- with(results, factor(c("May", "May", "June", "June",
                                     "August", "August", "September",
                                     "September"),
                                   levels = c("May", "June",
                                             "August", "September")))

p2 <- ggplot(data = results, aes(x = month, y = dose,
                                group = factor(p), fill = factor(p))) +
  geom_col(position = position_dodge(width = 0.9), colour = "#000000") +
  geom_errorbar(aes(ymin = (dose - LCL_dis), ymax = (dose + UCL_dis)),
               size = 0.4, width = 0.06,
               position = position_dodge(width = 0.9))

p2

```

 LC_probit

Lethal Concentration Probit

Description

Calculates lethal concentration (LC) and its fiducial confidence limits (CL) using a probit analysis according to Finney 1971, Wheeler et al. 2006, and Robertson et al. 2007.

Usage

```

LC_probit(formula, data, p = seq(1, 99, 1), weights,
          subset = NULL, het_sig = NULL, conf_level = NULL)

```

Arguments

formula	an object of class formula or one that can be coerced to that class): a symbolic description of the model to be fitted. The details of model specification are given under Details.
data	an optional data frame, list or environment (or object coercible by <code>as.data.frame</code> to a data frame) containing the variables in the model. If not found in data, the variables are taken from <code>environment(formula)</code> , typically the environment from which <code>LC_probit</code> is called.
p	Lethal Concentration (LC) value for given p, example will return a LC50 value if p equals 50. If more than one LC value wanted specify by creating a vector.
weights	vector of 'prior weights' to be used in the fitting process. Should be a numeric vector and is required for analysis.

subset	allows for the data to be subset if desired. Default set to NULL.
het_sig	significance level from person's chi square goodness-of-fit test that is used to decide if a heterogeneity factor is used. NULL is set to 0.15.
conf_level	Adjust confidence level as necessary or NULL set at 0.95.

Value

Returns a data frame with predicted LC for given p level, lower CL (LCL), upper CL (UCL), LCL and UCL distance away from LC (LCL_dis & UCL_dis; important for creating a plot), Pearson's chi square goodness-of-fit test, slope, intercept, slope and intercept p values and standard error, and LC variance.

References

- Finney, D.J., 1971. Probit Analysis, Cambridge University Press, Cambridge, England, ISBN: 052108041X
- Wheeler, M.W., Park, R.M., and Bailey, A.J., 2006. Comparing median lethal concentration values using confidence interval overlap or ratio tests, Environ. Toxic. Chem. 25(5), 1441-1444.10.1897/05-320R.1
- Robertson, J.L., Savin, N.E., Russell, R.M. and Preisler, H.K., 2007. Bioassays with arthropods. CRC press. ISBN: 9780849323317

Examples

```
head(lampreytox)

# within the dataframe used, control dose, unless produced a value
# during experimentation, are removed from the dataframe,
# as glm cannot handle values of infinite. Other statistical programs
# make note of the control dose but do not include within analysis

#calculate LC50 and LC99

m <- LC_probit((response / total) ~ log10(dose), p = c(50, 99),
              weights = total,
              data = lampreytox,
              subset = c(month == "May"))

#view calculated LC50 and LC99 for seasonal toxicity of a piscicide,
#to lamprey in 2011

m

#dose-response curve can be plotted using 'ggplot2'

library(ggplot2)

p1 <- ggplot(data = lampreytox[c(1:19), ],
             aes(x = log10(dose), y = (response / total))) +
  geom_point() +
```

```

geom_smooth(method = "glm",
            method.args = list(family = binomial(link = "probit")),
            aes(weight = total), colour = "#FF0000", se = TRUE)

p1

#calculate LC50s and LC99s for multiple toxicity tests, June, August, and September

j <- LC_probit((response / total) ~ log10(dose), p = c(50, 99),
             weights = total,
             data = lampreytox,
             subset = c(month == "June"))

a <- LC_probit((response / total) ~ log10(dose), p = c(50, 99),
             weights = total,
             data = lampreytox,
             subset = c(month == "August"))

s <- LC_probit((response / total) ~ log10(dose), p = c(50, 99),
             weights = total,
             data = lampreytox,
             subset = c(month == "September"))

#group results together in a dataframe to plot with 'ggplot2'

results <- rbind(m[, c(1, 3:8, 11)], j[,c(1, 3:8, 11)],
               a[, c(1, 3:8, 11)], s[, c(1, 3:8, 11)])

results$month <- with(results, factor(c("May", "May", "June", "June",
                                     "August", "August", "September",
                                     "September"),
                                 levels = c("May", "June",
                                             "August", "September")))

p2 <- ggplot(data = results, aes(x = month, y = dose,
                               group = factor(p), fill = factor(p))) +
  geom_col(position = position_dodge(width = 0.9), colour = "#000000") +
  geom_errorbar(aes(ymin = (dose - LCL_dis), ymax = (dose + UCL_dis)),
               size = 0.4, width = 0.06,
               position = position_dodge(width = 0.9))

p2

```

 LT_logit

Lethal Time Logit

Description

Calculates lethal time (LT) and its fiducial confidence limits (CL) using a logit analysis according to Finney 1971, Wheeler et al. 2006, and Robertson et al. 2007.

Usage

```
LT_logit(formula, data, p = seq(1, 99, 1), weights,
subset = NULL, het_sig = NULL, conf_level = NULL)
```

Arguments

formula	an object of class formula or one that can be coerced to that class: a symbolic description of the model to be fitted.
data	an optional data frame, list or environment (or object coercible by <code>as.data.frame</code> to a data frame) containing the variables in the model. If not found in data, the variables are taken from <code>environment(formula)</code> , typically the environment from which <code>LT_logit</code> is called.
p	Lethal time (LT) values for given p, example will return a LT50 value if p equals 50. If more than one LT value desired specify by creating a vector.
weights	vector of 'prior weights' to be used in the fitting process. Should be a numeric vector and is required for analysis.
subset	allows for the data to be subset if desired. Default set to NULL.
het_sig	significance level from person's chi square goodness-of-fit test that is used to decide if a heterogeneity factor is used. NULL is set to 0.15.
conf_level	Adjust confidence level as necessary or NULL set at 0.95.

Value

Returns a data frame with predicted LT for given p level, lower CL (LCL), upper CL (UCL), LCL and UCL distance away from LT (LCL_dis & UCL_dis; important for creating a plot), Pearson's chi square goodness-of-fit test, slope, intercept, slope and intercept p values and standard error, and LT variance.

References

Finney, D.J., 1971. Probit Analysis, Cambridge University Press, Cambridge, England, ISBN: 052108041X

Wheeler, M.W., Park, R.M., and Bailey, A.J., 2006. Comparing median lethal concentration values using confidence interval overlap or ratio tests, *Environ. Toxic. Chem.* 25(5), 1441-1444.10.1897/05-320R.1

Robertson, J.L., Savin, N.E., Russell, R.M. and Preisler, H.K., 2007. Bioassays with arthropods. CRC press. ISBN: 9780849323317

Examples

```
head(lampreytime)

results <- LT_logit((response / total) ~ log10(hour),
p = c(50, 99),
weights = total,
data = lampreytime,
subset = c(month == "May"))
```

```
#view calculated LT50 and LT99 for seasonal
#toxicity of a piscicide, 3-trifluoromethyl-4-nitrophenol, to lamprey in 2011

results

#dose-response curve can be plotted using 'ggplot2'
```

 LT_probit

Lethal Time Probit

Description

Calculates lethal time (LT) and its fiducial confidence limits (CL) using a probit analysis according to Finney 1971, Wheeler et al. 2006, and Robertson et al. 2007.

Usage

```
LT_probit(formula, data, p = seq(1, 99, 1), weights,
subset = NULL, het_sig = NULL, conf_level = NULL)
```

Arguments

formula	an object of class formula or one that can be coerced to that class: a symbolic description of the model to be fitted.
data	an optional data frame, list or environment (or object coercible by <code>as.data.frame</code> to a data frame) containing the variables in the model. If not found in data, the variables are taken from <code>environment(formula)</code> , typically the environment from which <code>LT_probit</code> is called.
p	Lethal time (LT) values for given p, example will return a LT50 value if p equals 50. If more than one LT value desired specify by creating a vector.
weights	vector of 'prior weights' to be used in the fitting process. Should be a numeric vector and is required for analysis.
subset	allows for the data to be subset if desired. Default set to NULL.
het_sig	significance level from person's chi square goodness-of-fit test that is used to decide if a heterogeneity factor is used. NULL is set to 0.15.
conf_level	Adjust confidence level as necessary or NULL set at 0.95.

Value

Returns a data frame with predicted LT for given p level, lower CL (LCL), upper CL (UCL), LCL and UCL distance away from LT (LCL_dis & UCL_dis; important for creating a plot), Pearson's chi square goodness-of-fit test, slope, intercept, slope and intercept p values and standard error, and LT variance.

References

- Finney, D.J., 1971. Probit Analysis, Cambridge University Press, Cambridge, England, ISBN: 052108041X
- Wheeler, M.W., Park, R.M., and Bailey, A.J., 2006. Comparing median lethal concentration values using confidence interval overlap or ratio tests, Environ. Toxic. Chem. 25(5), 1441-1444.10.1897/05-320R.1
- Robertson, J.L., Savin, N.E., Russell, R.M. and Preisler, H.K., 2007. Bioassays with arthropods. CRC press. ISBN: 9780849323317

Examples

```
head(lampreytime)

results <- LT_probit((response / total) ~ log10(hour),
  p = c(50, 99),
  weights = total,
  data = lampreytime,
  subset = c(month == "May"))

#view calculated LT50 and LT99 for seasonal
#toxicity of a piscicide, 3-trifluoromethyl-4-nitrophenol, to lamprey in 2011

results

#dose-response curve can be plotted using 'ggplot2'
```

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