Package ‘moult’

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moult-package

Methods for Estimating Start and Duration of Moult in Birds

Description

Functions for estimating the duration and mean start date for avian moult data, based on maximum likelihood.

Details

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LazyLoad: yes

Author(s)

Birgit Erni

References


date2days

Convert date to day count

Description

Convert date mm/dd/yyyy to days since the 1st of startmonth, starting with days = 1 for the 1st day of startmonth.

Usage

date2days(date, dateformat, startmonth)
moult

Models to analyse data of moult in birds

Description

Estimate duration and mean start date of moult from moult score data by maximum likelihood. Covariates to model duration and start of moult are possible.

Usage

```r
moult(formula, data, start = NULL, type = 2, method = "BFGS", fixed = NULL, fixed.val = NULL)
```

Arguments

- **formula** symbolic description of the model, see details.
- **start** starting values for parameters.
- **data** an optional data frame containing the variables in the model. If not found in data, the variables are taken from the environment from which moult was called.
- **type** integer (one of 1,2,3,4,5) referring to type of moult data and consequently model to be fitted (see details).
- **method** optimisation algorithm, passed to optim.
- **fixed** logical vector specifying which parameter values to fix during optimization.
- **fixed.val** numeric vector with values for the fixed parameters.

Examples

```r
date2days("01/01/2010", "dd/mm/yyyy", 1)
date2days("01-01-2010", "dd-mm-yyyy", 2)
date2days("2008/06/01", "yyyy/mm/dd", 8)  # year has no effect
```
Details

The formula is specified in 5 parts:
\[ \text{moult.index} \sim \text{days} \mid x_1 + x_2 \mid y_1 + y_2 \mid z_1 + z_2 \]
where \text{moult.index} is a numerical vector with values between 0 and 1, \text{days} is a vector with corresponding day numbers on which moult indeces were observed. The next three parts contain explanatory variables for modelling duration, mean start date and standard deviation in start date, respectively. If no explanatory variables are wanted for duration, say, this can be specified by leaving a blank between the first and second vertical lines, or equivalently, inserting a 1 between the vertical lines (which means all durations will be assumed equal). Similarly for mean start date and standard deviation. The minimum formula must contain \text{moult.index} \sim \text{days}, which will assume the same duration, mean start date and standard deviation for all individuals.

type refers to the type of moult data available (see Underhill and Zucchini (1998) and Underhill, Zucchini and Summers (1990)).

\text{type} = 1 \text{ sample is representative of entire population (not yet mouling, in moult, and birds which have completed moult). For type 1 data, any value between 0 and 1 (> 0 and < 1) can be used as the moult index for birds in active moult. The value used does not matter, only the fact that they are in moult.}

\text{type} = 2 \text{ (default) sample is representative of entire population (not yet moulling, in moult, and birds which have completed moult). Moult scores are required.}

\text{type} = 3 \text{ sample is representative only of birds in moult. Individuals with moult scores 0 or 1 are ignored.}

\text{type} = 4 \text{ sample is representative only of birds in moult and those that have completed moult. Individuals with moult scores 0 are ignored.}

\text{type} = 5 \text{ sample is representative only of birds that have not started moult or that are in moult. Individuals with moult scores 1 are ignored.}

To fix parameters fixed will be a logical vector, e.g. fixed = c(F, F, T), fixed.val = 3.5 will fix the standard deviation in start date to exp(3.5) and only estimate the remaining two parameters.
moult uses the R function \text{optim} to minimise the negative log-likelihood.

Note: The standard deviation parameters are estimated on the log-scale. Thus the corresponding elements in the covariance matrix are also on the log-scale. Standard errors for the standard deviation parameters are on the scale of the standard deviation (in days), estimated using the delta method.

Value

- \text{coefficients}: parameter estimates split up into duration, mean start date and standard deviation of start date.
- \text{loglik}: log-likelihood at parameter estimates.
- \text{vcov}: variance covariance matrix for parameter estimates.
- \text{standard.errors}: vector of standard errors for parameter estimates, obtained from diagonal elements of vcov, see details.
- \text{type}: type of data assumed, see details.
residuals vector of residuals: observed - fitted moult index.
fitted.values a vector of fitted values (moult scores).
n number of observations.
df.residual residual degrees of freedom for fitted model.
terms duration formula, mean formula, full formula.
mean.formula model formula for mean start date.
duration.formula model formula for duration of moult.
formula model formula for mean start and duration of moult.
.sd.formula grouping variable used to estimate standard deviations in mean start dates, different for each group.
optim object returned by call to optim, which minimises negative log-likelihood.
converged logical value indicating whether algorithm has converged or not.
convergence.value value for convergence returned by optim, see optim for details.

Author(s)

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References


See Also

predict.moult, msRpfmg

Examples

data(sanderlings)
m2 <- moult(MIndex ~ Day, data = sanderlings)
summary(m2)
ms2pfmg

Convert moult scores to proportion of feather mass grown

Description

Convert moult scores obtained for single feathers into overall proportion of feather mass grown.

Usage

ms2pfmg(ms, fm)

Arguments

ms vector of moult scores. Ideally, each moult score is a character string of one individual's individual feather moult scores, each between 0 and 5, e.g. "555444000" if only nine primaries are of interest.

fm vector of relative feather mass, corresponding to each feather in ms.

Details

ms will usually be a vector of 9 or 10 primary feather scores, but single feathers can be given, in which case fm is ignored. The method used here assumes that a moult score of 1 for any feather corresponds to 1/8th of the feather grown, 2 corresponds to 3/8th = 0.375, etc.. The proportion of feather mass grown is then a weighted sum over all feathers, with weights equal to the relative weight (compared to the total weight) of each feather (Underhill and Zucchini 1988).

Value

ms2pfmg returns a single value between 0 and 1: proportion of total feather mass grown.

Author(s)

Bo T. Bonnevie

References


See Also

predict.moult, moult
Examples

```r
## relative primary feather mass of the 10 primary feathers
## (as proportion of total feather mass) for Sanderlings
fm.sand <- c(0.0385, 0.0458, 0.0544, 0.0680, 0.0827, 0.1019, 0.1199, 0.1417, 0.1604, 0.1867)

ms2pfmg(3, 0.2)  # single feather
ms2pfmg(3, 1)
ms2pfmg("5555500000", fm.sand)
```

### predict.moult

Predict method for moult models

#### Description

Predict either the proportion of birds in a certain moult stage (as defined in intervals) on a specified day, the average moult score on a specified day, or start and/or duration of moult for given covariate patterns.

#### Usage

```r
## S3 method for class 'moult'
predict(object, newdata, predict.type = "prob", intervals = 0.1, ...)
```

#### Arguments

- `object`: moult model objects
- `newdata`: optional dataframe with explanatory variables for which to make predictions. Note the first column must contain the days (as used when fitting) for which to make predictions.
- `predict.type`: specifies form of predictions, see details.
- `intervals`: length of moult categories for which probabilities/proportions should be calculated. The default (= 0.1) will calculate the probability that a bird will fall in this moult category on the specified day for each of the following categories: 0, (0, 0.1), [0.1, 0.2), [0.2, 0.3), ..., [0.9, 1.0), 1.
- `...`: other arguments passed to the predict method

#### Details

`predict.type` has the following options:

- "response" the average moult index (proportion of feather mass grown) for each of the days specified.
- "prob" default, the proportion of birds in each of the moult categories as defined by intervals is predicted.
"duration" predicts the duration of moult for the covariate combinations defined in newdata, with standard errors.

"start" predicts the mean start date of moult for the covariate combinations defined in newdata, with standard errors.

"both" predicts both mean start date of moult and duration of moult for the covariate combinations defined in newdata, with standard errors. Also, covariance of duration and start date estimates is given.

Value

If predict.type = "response", or newdata is missing, the expected moult scores at the specified days are returned.

If predict.type = "prob" a matrix of predicted probabilities for being in each of the moult categories defined by intervals.

If predict.type equals "start" or "duration" or "both", the corresponding estimates (with standard errors) for each of the covariate patterns are returned.

Author(s)
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References


See Also
moult

Examples

data(sanderlings)

m2 <- moult(MIndex ~ Day, data = sanderlings)
m3 <- moult(MIndex ~ Day, data = sanderlings, type = 3)

## number of birds observed on each of the days
(nn <- as.numeric(table(sanderlings$Day)))

## unique observation days
(day <- unique(sanderlings$Day))
sanderlings

## Table 6 in Underhill and Zucchini 1988
## expected number of birds in each moult stage on each day
p1 <- predict(m2, newdata = data.frame(day))
p1$pM * nn

## Table 7 in Underhill and Zucchini 1988
## expected number of birds in each moult stage for days 70 to 310
days2 <- seq(70, 310, by = 10)
p2 <- predict(m2, newdata = data.frame(days2))
p2$pM * 100

(p3 <- predict(m3, newdata = data.frame(day)))

---

### Sanderling Moult Data

#### Description
This data set gives moult indices for 164 Sanderlings trapped on 11 days.

#### Usage
data(sanderlings)

#### Format
A data frame with 164 observations on the following 2 variables.

- **day**: a numeric vector of day bird was measured, 1 = 1 July
- **mindex**: a numeric vector of moult indices, 0 = bird has not started moult, 1 = bird has completed moult

#### Details
This data set gives moult indices for 164 Sanderlings trapped on 11 days in the southwestern Cape, South Africa, between October 1978 and April 1979. Day 1 = 1 July. Moult indices are a transformation of moult scores so that moult index increases linearly with time. See Underhill and Zucchini (1988) for details.

#### Source
Underhill and Zucchini (1998)

#### References
Examples

data(sanderlings)

## fit model of type 1 to data
m1 <- moult(MIndex ~ Day, data = sanderlings, type = 1)
summary(m1)

## model of type 2 (default)
m2 <- moult(MIndex ~ Day, data = sanderlings)
summary(m2)

## model of type 3
m3 <- moult(MIndex ~ Day, data = sanderlings, type = 3)
summary(m3)

## find intercept and slope of mean moult trajectory line
uza <- - coef(m2, "mean") / coef(m2, "duration")
uzb <- 1 / coef(m2, "duration")

## extract how many birds observed on each of the days
nn <- as.numeric(table(sanderlings$Day))
## extract days of observations
day <- unique(sanderlings$Day)

## probabilities of moult stages
## Table 6 in Underhill and Zucchini 1988
p1 <- predict(m2, newdata = data.frame(day))
p1$M * nn

## Table 7 in Underhill and Zucchini 1988
days2 <- seq(70, 310, by = 10)
p2 <- predict(m2, newdata = data.frame(days2))
p2$M * 100

p3 <- predict(m3, newdata = data.frame(day))
p3

## Comparison with regression models
MInd <- sanderlings$MIndex[sanderlings$MIndex > 0 &
    sanderlings$MIndex < 1]
MTime <- sanderlings$Day[sanderlings$MIndex > 0 &
    sanderlings$MIndex < 1]

lm1 <- lm(MTime ~ MInd)
lm1.int <- coef(lm1)[1]
lm1.slope <- coef(lm1)[2]

lm2 <- lm(MInd ~ MTime)

## regression of Index on Time
plot(MTime, MInd, pch = 19, cex=0.7)
## Regression of Time on Index: gives better estimates
## for mean start day and duration of moult

```r
abline(lm2, col = "blue", lwd = 2)
abline(-lm1.int / lm1.slope, 1 / lm1.slope, col = "orange", lwd = 2)
abline(za, zb, col = "red", lty = 2, lwd = 2)
```

---

### Description

Weaver moult data from the Western Cape, South Africa

### Usage

```r
data(weavers)
```

### Format

A data frame with 7543 observations on the following 4 variables.

- **rdate**: a character vector with dates on which individuals were caught, format: yyyy-mm-dd.
- **sex**: a numeric vector, 0 = unknown, 1 = male, 2 = female, 3 = possibly male, 4 = possibly female.
- **year**: year in which individual was caught.
- **moult**: a character vector with moult scores for individual primary feathers, either nine or ten, starting with innermost primary feather. 0: old feather, 5: new feather, 1 to 4, feathers at various stages of growth in between.

### Source


### Examples

```r
data(weavers)
head(weavers)
if(is.numeric(weavers$moult)) {
  scores <- format(weavers$moult, scientific = FALSE, trim = TRUE)
} else {
  scores <- weavers$moult
}
m scores <- substr(scores, 1, 9)
feather.mass <- c(10.4, 10.8, 11.5, 12.8, 14.4, 15.6, 16.3, 15.7, 15.7)
```
## convert moult scores to proportion of feather mass grown

```r
weavers$pfmg <- ms2pfmg(mscores, feather.mass)
weavers$day <- date2days(weavers$RDate, dateformat = "yyyy-mm-dd", startmonth = 8)
ssex <- ifelse(weavers$Sex == 1 | weavers$Sex == 3, "male",
               ifelse(weavers$Sex == 2 | weavers$Sex == 4, "female", NA))
weavers$ssex <- as.factor(ssex)
```

## model with duration and mean start date of moult depending on sex

```r
mmf <- moult(pfmg ~ day | ssex | ssex, data = weavers, type = 3)
summary(mmf)
```

## predict duration and start of moult (then both) for males and females

```r
ssex <- c("male", "female")
day <- 150
(p1 <- predict.moult(mmf, newdata = data.frame(day, ssex), predict.type = "duration"))
(p2 <- predict.moult(mmf, newdata = data.frame(day, ssex), predict.type = "start"))
(p3 <- predict.moult(mmf, newdata = data.frame(day, ssex), predict.type = "both"))
```
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