Package ‘MASSTIMATE’

August 29, 2016

Type Package
Title Body Mass Estimation Equations for Vertebrates
Version 1.3
Date 2016-01-13
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Depends R (>= 2.10.0)
Description Estimation equations are from a variety of sources but are, in general, based on regressions between skeletal measurements (e.g., femoral circumference) and body mass in living taxa.
License GPL (>= 2)
NeedsCompilation no
Repository CRAN
Date/Publication 2016-01-13 08:49:39

R topics documented:

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**Description**

Estimation equations are from a variety of sources but are, in general, based on regressions between skeletal measurements (e.g., femoral circumference) and body mass in living taxa.

**Details**

- **Package:** MASSTIMATE
- **Type:** Package
- **Version:** 1.3
- **Date:** 2016-01-13
- **License:** GPL(>= 2)

**Author(s)**

Nicolas E. Campione

Maintainer: Nicolas E. Campione <nicolas.campione@geo.uu.se>

**References**


Body Mass Estimates Using Anderson et al. (1985)

Description

This function estimates body mass based on humeral and/or femoral circumferences using the quadrupedal and bipedal equations of Anderson et al. (1985)

Usage

ahrQ98UHhc \[ \text{nullL fcL equation \[ c("bip", "quad"), data=NULL} \]

Arguments

- **hc**: an optional value or vector representing humeral circumference (in mm)
- **fc**: a value or vector representing femoral circumference (in mm)
- **equation**: desired estimation equation. Two possible choices: "quad", "bip"
- **data**: an optional object of class = "data.frame" or class = "matrix"

Details

If equation = "bip" then only femoral circumference is needed. Both humeral and femoral circumference are needed to estimate body mass of a quadruped (equation = "quad"). If a data object is specified, the mass estimates will be added as a column to the data.frame or matrix within that object.

Value

ahrQ98U A numeric value or vector representing the mass estimate(s) in grams

Author(s)

Nicolas E. Campione

References


See Also

QE cQE quadrupeds bipeds CM1992 CF2004 MCF2004
Examples

```r
# Quadrupedal dinosaurs
data(dinos)
AHR1985(dinos$HC, dinos$FC, equation = "quad", data = dinos)

# Bipedal dinosaurs
data(dinosbip)
AHR1985(HC=NULL, dinosbip$FC, equation = "bip", data = dinosbip)
```

```
---
---

Description

This function returns body mass estimates for bipeds based on minimum femoral circumference using a set of five equations (intended for non-avian dinosaurs)

Usage

```r
bipeds(FC, cQE.eq = "raw", cQE.cor = 2, data = NULL)
```

Arguments

- `FC`: a value or vector representing femoral circumference (should be in mm)
- `cQE.eq`: desired estimation equation for the cQE. Two possible choices (See `cQE`). "raw" is default
- `cQE.cor`: correction factor to be used ($\alpha^2$). The default is 2, as per Campione et al. (2014)
- `data`: an optional object of class = "data.frame" or class = "matrix"

Details

This function returns estimates from five equations intended for terrestrial bipeds (in particular non-avian dinosaurs): Campione et al. (2014); Campione (in review); Anderson et al. (1985); Christiansen and Farina (2004); Campbell and Marcus (1992). For more details please see the specific functions.

If a data object is specified, the mass estimates and additional results will be added as columns to the data.frame or matrix within that object.

Value

Nine numeric values or columns are returned (all masses are in grams):

- `cQE`: A numeric value or vector of mass estimates using cQE
- `upper.cQE`: A numeric value or vector representing the upper prediction error of the cQE based on that derived for the specific equation in Campione and Evans (2012)
- `lower.cQE`: A numeric value or vector representing the lower prediction error of the cQE
cfRPPT


Description

This function is meant for bipedal mass estimate (in particular theropod dinosaurs) and presently only estimates body mass based on the femoral circumference equation of Christiansen and Farina (2004) derived from volumetric reconstructions of theropod dinosaurs.

Usage

CF2004(FC, data = NULL)
Arguments

- **FC** a value or vector representing femoral circumference (in mm)
- **data** an optional object of class = "data.frame" or class = "matrix"

Details

If a data object is specified, the mass estimates will be added as a column to the data.frame or matrix within that object.

Value

**CF2004** A numeric value or vector representing the mass estimate(s) in grams

Author(s)

Nicolas E. Campione

References


See Also

cQE bipeds AHR1985 CM1992

Examples

```r
## Bipedal dinosaurs
data(dinosbip)
CF2004(dinosbip$FC, data = dinosbip)
```

Description

This function estimates body mass based on femoral circumference using the avian equation of Campbell and Marcus (1992)

Usage

```r
CM1992(FC, data = NULL)
```

Arguments

- **FC** a value of vector representing femoral circumference (in mm)
- **data** an optional object of class = "data.frame" or class = "matrix"
Details

If a data object is specified, the mass estimates will be added as a column to the data.frame or matrix within that object.

Value

CM1992 A numeric value or vector representing the mass estimate(s) in grams

Author(s)

Nicolas E. Campione

References


See Also

cQE bipeds AHR1985 CF2004

Examples

```r
# Bipedal dinosaurs
data(dinosbip)
CM1992(dinosbip$FC, data = dinosbip)
```

---

**cQE**

*Body Mass Estimates Using Bipedal Correction Factor*

Description

This function presents equations from Campione et al. (2014) for estimating body mass in bipeds using minimum femoral circumference and based on a correction of the quadrupedal equations from Campione and Evans (2012).

Usage

cQE(FC, equation = "raw", cor = 2, quadratic = FALSE, data = NULL)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC</td>
<td>a value or vector representing femoral circumference (in mm)</td>
</tr>
<tr>
<td>equation</td>
<td>desired estimation equation. Two possible choices (See Details)</td>
</tr>
<tr>
<td>cor</td>
<td>correction factor to be used ($\alpha^2$). The default is 2, as per Campione et al. (2014)</td>
</tr>
<tr>
<td>quadratic</td>
<td>a logical indicating whether estimates based on the quadratic equation should be used (See Details)</td>
</tr>
<tr>
<td>data</td>
<td>an optional object of class = &quot;data.frame&quot; or class = &quot;matrix&quot;</td>
</tr>
</tbody>
</table>
Details

The function includes two different equations. equation = "raw" (default) applies the correction factor derived in Campione et al. (2014) to the raw (non-phylogenetically corrected) bivariate regression equation from Campione and Evans (2012). equation = "phylocor" applies the same correction factor to the phylogenetically corrected equation presented in the same study.

cor = 2 refers to the correction factor ($\alpha^2$) to be used. The default (cor = 2) refers the initial derivation in Campione et al. (2014), however, this value can be modified based on the level of eccentricity of the femur. A set of values for cor corresponding to set eccentricities can be found in table S2 of Campione et al. (2014).

If quadratic = TRUE, then a second set of estimates will be returned based on a quadratic estimation equation (Campione in review).

If a data object is specified, the mass estimates and additional results will be added as columns to the data.frame or matrix within that object.

Value

Eight numeric values or columns are returned if quadratic = TRUE (identified by q):

1. **log . cQE**: A numeric value or vector representing the mass estimate(s) in log10 grams
2. **cQE**: A numeric value or vector representing the mass estimate(s) in grams
3. **lower . cQE**: A numeric value or vector representing the lower prediction error derived for the specific equation in Campione and Evans (2012)
4. **upper . cQE**: A numeric value or vector representing the upper prediction error
5. **log . qcQE**: A numeric value or vector representing the mass estimate(s) in log10 grams using a quadratic equation
6. **qcQE**: A numeric value or vector representing the mass estimate(s) in grams
7. **lower . qcQE**: A numeric value or vector representing the lower prediction error derived for the specific equation by Campione (in review)
8. **upper . qcQE**: A numeric value or vector representing the upper prediction error

Author(s)

Nicolas E. Campione

References


See Also

QE bipeds AHR1985 CF2004 CM1992

Examples

```r
# Bipedal dinosaurs
data(dinosbip)

# Estimates for Tyrannosaurus (FMNH PR 2081 "Sue")
Sue<-which(dinosbip$Taxon=="TyrannosaurusFMNH2081")
cQE(dinosbip$FC[Sue]) # default correction factor

cQE(dinosbip$FC[Sue], cor = 1.815) # based on eccentricity of the femur

# Estimates of bipedal dinosaurs using phylogenetically corrected linear and quadratic equations
cQE(dinosbip$FC, equation = "phylocor", cor = dinosbip$cor, quadratic = TRUE, data = dinosbip)
```

---

**dinos**

*Dinosaur data from Campione and Evans 2012*

---

**Description**

Humeral and Femoral circumference data for eight quadrupedal dinosaurs

**Usage**

`data(dinos)`

**Format**

A data frame with 8 observations and the following 3 variables.

- **Taxon** a factor with levels *Brachiosaurs* *Corythosaurus* *Diplodocus* *Iguanodon* *Protoceratops* *Stegosaurus* *Styracosaurus* *Triceratops*
- **HC** a numeric vector of humeral circumferences
- **FC** a numeric vector of femoral circumferences

**Source**

dinosbip  

*Description*

Femoral circumference data for 34 bipedal dinosaurs

*Usage*

```r
data(dinosbip)
```

*Format*

A data frame with 34 observations and the following 3 variables.

- **taxon**: a factor with the taxon names
- **fc**: a numeric vector of femoral circumferences
- **cor**: a numeric vector with the correction factor \( \alpha^2 \) values to be used in cQE

*Source*


---

MCF2004  

*Description*

This function is meant for quadrupedal mass estimates (in particularly sauropod dinosaurs) and presently only estimates body mass based on the femoral circumference equation of Mazzetta et al. (2004) derived from volumetric reconstructions of sauropod dinosaurs

*Usage*

```r
MCF2004(FC, data = NULL)
```

*Arguments*

- **FC**: a value or vector representing femoral circumference (in mm)
- **data**: an optional object of class = "data.frame" or class = "matrix"
Details

If a data object is specified, the mass estimates will be added as a column to the data.frame or matrix within that object.

Value

MCF2004 A numeric value or vector representing the mass estimate(s) in grams

Author(s)

Nicolas E. Campione

References


See Also

QE quadrupeds MR AHR1985

Examples

```r
# Quadrupedal dinosaurs
data(dinos)
MCF2004(dinos$FC, data = dinos)
```

Description

This function presents the multiple regressions equations from Campione and Evans (2012) for estimating body mass in terrestrial vertebrates using humeral and femoral circumferences

Usage

```r
MR(HC, FC, equation = c("raw","phylocor"), data = NULL)
```

Arguments

- **HC**: a value or vector representing humeral circumference (in mm)
- **FC**: a value or vector representing femoral circumference (in mm)
- **equation**: desired estimation equation. Two possible choices (See Details)
- **data**: an optional object of class = "data.frame" or class = "matrix"
Details

The function includes two different equations. \texttt{equation = "raw"} applies the multiple regression based on the raw (non-phylogenetically corrected) relationship - equation 5 of Campione and Evans (2012). \texttt{equation = "phylocor"} applies the multiple regressions taking phylogenetic relationships into account - equation 6 of Campione and Evans (2012).

If a data object is specified, the mass estimates and additional results will be added as columns to the data.frame or matrix within that object.

Value

Four numeric values or columns are returned:

\begin{itemize}
  \item \texttt{log.masstimate} \hspace{1em} A numeric value or vector representing the mass estimate(s) in log10 grams
  \item \texttt{MR} \hspace{1em} A numeric value or vector representing the mass estimate(s) in grams
  \item \texttt{upper.MR} \hspace{1em} A numeric value or vector representing the upper prediction error based on that derived for the specific equation by Campione and Evans (2012)
  \item \texttt{lower.MR} \hspace{1em} A numeric value or vector representing the lower prediction error
\end{itemize}

Author(s)

Nicolas E. Campione

References


See Also

\texttt{QE quadrupeds AHR1985 MCF2004}

Examples

```r
# Dinosaur data from Campione and Evans (2012) for quadrupedal dinosaurs
data(dinos)

# Combined equation based on the raw regression
MR(dinos$HC, dinos$FC, equation = "raw", data = dinos)

# Combined equation based on the phylogenetically corrected regression, data not specified
MR(dinos$HC, dinos$FC, equation = "phylocor")
```
**Description**

This function calculates the percent prediction error of a sample based on the predicted and true values.

**Usage**

```r
ppe(true, pred, abs = TRUE)
```

**Arguments**

- `true`: a numeric vector representing the true value on which a prediction (`pred`) will be compared.
- `pred`: a numeric vector with the predicted values, must be equal length to `true`.
- `abs`: a logical value indicating whether to return the absolute values for `ppe`, default is `abs = TRUE`.

**Details**

This function calculates the percent prediction error (`ppe`) as a scaled residual (Smith 1980), generally based on the absolute residual, so:

\[
ppe = \frac{|true - pred|}{pred} \times 100
\]

**Value**

Function returns a list of results, including a list of all the percent prediction errors, along with the mean, 95 percent confidence intervals, range, and standard deviation.

**Author(s)**

Nicolas E. Campione

**References**


**See Also**

`see`
Body Mass Estimates Using Combined Humeral and Femoral Circumferences

Description
This function is based on the bivariate regression equations from Campione and Evans (2012) for estimating body mass in terrestrial vertebrates using the combined humeral and femoral circumferences.

Usage
```r
QE(HFC = NULL, HC, FC, equation = "raw", quadratic = FALSE, data = NULL)
```

Arguments
- `HFC`: a value or vector representing the combined humeral and femoral circumferences
- `HC`: a value or vector representing humeral circumference (in mm)
- `FC`: a value or vector representing femoral circumference (in mm)
- `equation`: desired estimation equation. Two possible choices (See Details)
- `quadratic`: a logical indicating whether estimates based on the quadratic equation should be used (See Details)
- `data`: an optional object of class = "data.frame" or class = "matrix"

Details
The function includes two different equations. `equation = "raw"` (default) applies the non-phylogenetically corrected regression equation - equation 1 of Campione and Evans (2012). `equation = "phylocor"` applies the phylogenetically corrected regression equation - equation 2 of Campione and Evans (2012).

If `HFC` is specified, then `HC` and `FC` are ignored.
If `quadratic = TRUE`, then a second set of estimates will be returned based on a quadratic view of the Campione and Evans (2012) data set (Campione in review).
If a data object is specified, the mass estimates and additional results will be added as columns to the data.frame or matrix within that object.

Value
Eight numeric values or columns are returned if `quadratic = TRUE` (identified by `q`):
- `log.QE`: A numeric value or vector representing the mass estimate(s) in log10 grams
- `QE`: A numeric value or vector representing the mass estimate(s) in grams
- `lower.QE`: A numeric value or vector representing the lower prediction error derived for the specific equation by Campione and Evans (2012)
This function returns body mass estimates for quadrupeds using humeral and/or femoral circumferences (intended for non-avian dinosaurs)

**Usage**

quadrupeds(HC, FC, QE_MR.eq = "raw", data = NULL)
Arguments

HC  a value or vector representing humeral circumference (in mm)
FC  a value or vector representing femoral circumference (in mm)
QE_MR.eq  desired estimation equations to used by QE and MR. Two possible choices. "raw" is default
data  an optional object of class = "data.frame" or class = "matrix"

Details

This function returns estimates from five equations intended for terrestrial quadrupeds (in particular non-avian dinosaurs): two from Campione and Evans (2012) based on bivariate and multiple regression approaches; a quadratic view of the bivariate regression (Campione in review); Anderson et al. (1985); Mazzetta et al. (2004). For more details please see the specific functions.

If a data object is specified, the mass estimates and additional results will be added as columns to the data.frame or matrix within that object.

Value

11 numeric values or columns are returned (all masses are in grams):

QE  A numeric value or vector of mass estimates using QE (bivariate regression)
upper.QE  A numeric value or vector representing the upper prediction error of the QE based on that derived for the specific equation by Campione and Evans (2012)
lower.QE  A numeric value or vector representing the lower prediction error of the QE
qQE  A numeric value or vector of mass estimates using qQE (quadratic equation)
upper.qQE  A numeric value or vector representing the upper prediction error of qQE derived for the specific equation in Campione (in review)
lower.qQE  A numeric value or vector representing the lower prediction error of qQE
MR  A numeric value or vector of mass estimates using MR (multiple regression)
upper.MR  A numeric value or vector representing the upper prediction error of the MR based on that derived for the specific equation by Campione and Evans (2012)
lower.MR  A numeric value or vector representing the lower prediction error of the MR
AHR1985  A numeric value or vector of mass estimates using Anderson et al. (1985)
MCF2004  A numeric value or vector of mass estimates using Mazzetta et al. (2004)

Author(s)

Nicolas E. Campione
References


See Also

QE MR AHR1985 MCF2004

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Standard Error of the Estimate

Description

This function computes the standard error of the estimate based on the actual and predicted values.

Usage

`see(true, pred)`

Arguments

- `true`: a numeric vector representing the true values
- `pred`: a numeric vector representing the predicted values, must be equal length to `true`

Details

This function calculates the standard error of the estimate (`see`) as a scaled residual, so:

```
see = \sqrt{\frac{\sum (true - pred)^2}{N}}
```

Value

Function returns a length one value of the standard error of the estimate.

Author(s)

Nicolas E. Campione
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