

Package ‘pollimetry’

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Type Package

Title Estimate Pollinator Body Size and Co-Varying Ecological Traits

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Description Tools to estimate pollinator body size and co-varying traits. This package contains novel Bayesian predictive models of pollinator body size (for bees and hoverflies) as well as preexisting predictive models for pollinator body size (currently implemented for ants, bees, butterflies, flies, moths and wasps) as well as bee tongue length and foraging distance, total field nectar loads and wing loading. An additional GitHub repository <<https://github.com/liamkendall/pollimetrydata>> provides model objects to use the bodysize function internally. All models are described in Kendall et al (2018) <[doi:10.1101/397604](https://doi.org/10.1101/397604)>.

Depends R (>= 3.0.0), brms (>= 2.4.0)

Imports stats, repmis

Suggests rstan, pollimetrydata

License GPL (>= 2)

LazyData true

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bodysize	<i>Converts the intertegular distance (IT) and co-variates to body size in dry weight (mg) for bees or hoverflies.</i>
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Description

Calculates body size in dry weight (mg) from Kendall et al. (2018) using ITD (and co-variate) values.

Usage

```
bodysize(x, taxa, type)
```

Arguments

x	A data frame with columns containing 'IT' values and Sex ('Male' or 'Female'). Optional attributes depending on model choice: Taxonomy ('Family' for bees or 'Subfamily for hoverflies), 'Region' (Currently only "NorthAmerica", "SouthAmerica", "Australasia" and "Europe" implemented) and 'Species' ("Genus_species" format). Non-implemented regions and/or species are acceptable. See details.
taxa	A vector specifying insect taxa of interest, can be either "bee" for bee models and "hov" for hoverfly models
type	A vector specifying model type to be used: for bees this can be either "taxo" for the full taxonomic model, "phy" for the full phylogenetic model, "sex" for the reduced sexual dimorphic model or "IT" for the ITD-only model. In hoverflies: it can either be "taxo" for the full taxonomic model, "sex" for the reduced sexual dimorphic model or "IT" for the ITD-only model.

Details

For bees, type option 'taxo' requires IT, sex and taxonomic family. Type option 'phylo' only requires ITD and Sex to run but should be only be used for with Species (and Region) included in model formulation n.b. the function checks for contained species.

For hoverflies, type 'taxo' requires ITD, Subfamily and Sex for each specimen. Type "ITD" for both taxa only requires ITD values (Optional: region and species but check 'setdiff'). If specimens are from included regions or species (see above) we recommend including these as additional columns. Estimates (and variance components) are returned as four additional columns bound to the original

dataframe. In the likely case that non-represented taxa and regions are included in inputted datasets, 'allow_new_levels' is set to true for all models. Estimates will then be modelled with group-level uncertainty in the predictions based on the variation of the existing levels. This function makes use of external model objects hosted on GitHub. In the case of slow loading, we recommend you download the pollimetrydata package from <https://github.com/liamkendall/pollimetrydata>.

Value

The original dataframe (x) is returned along with four additional columns: body size (dry weight (mg)), S.E. and 90

References

Kendall et al. (2018) Pollinator size and its consequences: Predictive allometry for pollinating insects. <doi:10.1101/397604>

Examples

```
example=cbind.data.frame(IT=c(1.3,2.3),
                          Sex=c("Female","Male"),
                          Subfamily=c("Syrphinae","Eristalinae"),
                          Region=c("Australasia","Europe"),
                          Species=c("Sphaerophoria_macrogaster","Myathropa_florea"))
bodysize(x=example, taxa="hov", type="taxo")
```

foragedist

Converts body weight to measures of foraging distance for bees.

Description

Calculates foraging distance from Greenleaf et al. (2007) using intertegular distance (ITD) values, van Nieuwstadt and Iraheta (1996) using head width (HW) values for Meliponini (stingless bees) and Guedot et al. (2009) using dry weight (mg) values for Osmia species.

Usage

```
foragedist(x, type = "GreenleafAll")
```

Arguments

x	A vector of either bee intertegular spans (IT) measurements in cm, head width values in mm or dry weight values (mg).
type	The type of foraging distance desired. Options are "GreenleafAll", GrMhd ("Maximum homing distance"), GrThd ("Typical homing distance"), GrMfd ("Maximum feeder training distance"), GrMcd("Maximum communication distance"), "Osmia", "MeliMR", "MeliFT" or "MeliAll". See details in Greenleaf et al. (2007), Guedot et al. (2009) and van Nieuwstadt and Iraheta (1996).

Value

A dataframe with bee and foraging distance (Km) is returned for each bees species.

References

Kendall et al. (2018) Pollinator size and its consequences: Predictive allometry for pollinating insects. <doi:10.1101/397604>

Greenleaf et al. (2007) Bee foraging ranges and their relationship to body size. *Oecologia*, 153, 589-596. <doi:10.1007/s00442-007-0752-9>

Guedot et al. (2009). Relationship between body size and homing ability in the genus *Osmia* (Hymenoptera; Megachilidae). *Ecological Entomology*, 34(1), 158-161. <doi:10.1111/j.1365-2311.2008.01054.x>

van Nieuwstadt, M. G. L., & Iraheta, C. R. (1996). Relation between size and foraging range in stingless bees (Apidae, Meliponinae). *Apidologie*, 27(4), 219-228.

Examples

```
foragedist(c(10,5,2), type = "MeliMR")
```

headwidthsize	<i>Converts pollinator (Diptera, Hymenoptera and Lepidoptera) head width (mm) to body size (dry weight (mg)).</i>
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Description

Calculates dry body weight (mg) using head width (mm) from Hodar (1997).

Usage

```
headwidthsize(HW, Eq = "H97DB")
```

Arguments

HW	A vector of head width measurements (mm).
Eq	a vector of predictive allometries for insect taxa from Hodar (1997). Options implemented are: H97DB (Brachycera), H97DN (Nematocera), H97HA (Hymenoptera), H97LH (Heterocera) and H97LR (Rhopalocera).

Value

A dataframe with pollinator body size as dry weight (mg) is returned for each specimen from selected equation.

References

Kendall et al. (2018) Pollinator size and its consequences: Predictive allometry for pollinating insects. <doi:10.1101/397604>

Hodar, J. A. (1997). The use of regression equations for the estimation of prey length and biomass in diet studies of insectivore vertebrates. *Miscellanea Zoologica*, 20(2), 1-10.

Examples

```
headwidthsize(HW=c(10,5,2), Eq = c("H97DB"))
```

lengthsize	<i>Converts body length to body size (body weight (mg)) for three pollinating insect groups (Diptera, Hymenoptera and Lepidoptera).</i>
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Description

Calculates body size as dry weight (mg) from existing allometries (See 'Details') using body length values (mm).

Usage

```
lengthsize(BL, Eq = "DIP")
```

Arguments

BL	A vector of pollinator body length (BL) measurements (mm).
Eq	A vector specifying which predictive allometry to use. Acronyms denote first (and second author), publication date and taxon. DIP, HYM and LEP options are cases where authors modelled body size across all specimens within each order. Options implemented are: DIP (10 equations): BN06D, G97D, GR84D, JS00DA, R77D, S80DCF, S80DCR, S80DMF, S93DA, W13D) Brachycera (2 equations): S93DB, Sabo02DB Nematocera (3 equations): JS00DN, S93DN, Sabo02DN; Asilidae (2 equations): Sabo02DA, S93DB; Bombyliidae (2 equations): S93DB, Sabo02DBB; Cyclorrapha: S93DC HYM (12 equations): BN06H1, G97H, G97F, GR84H, JS00HA, R77H, S80HCF, S80HCR, S80HMF, S93HA, Sabo02H, W13H Formicidae (13 equations): BN06HF, GR84F, JS00HF, R77A, S80FCF, S80FCR, S80FMF, S93HF, S93HH, S93HI, BN06H1, G97H, G97F Apidae: Sabo02HA; Braconidae: S93HB; Halictidae: S93HH; Ichneumonidae: S93HI; Pompilidae: S93HP; Vespidae: S93HV and Sabo02HV LEP(9 equations): BN06L,G97L,JS00L,R77L,S80LCF, S80LCR, S80LMF,S93LA,W13L Noctuidea: S93LC, S93LN; Geometridae: S93LG; Microlepidoptera: S93LM; Arctiinae: S93LC.

Value

A dataframe with pollinator body size (mg) is returned for each species from selected equation/s.

References

Full reference list is available within Kendall et al. (2018) Pollinator size and its consequences: Predictive allometry for pollinating insects. <doi:10.1101/397604>

Examples

```
lengthsize(BL=c(10,5,2), Eq = c("S80DCR"))
```

lengthwidthsize	<i>Converts pollinator body length*body width to body size (dry weight (mg)).</i>
-----------------	---

Description

Calculates body size as dry weight (mg) from the equations described by Sample (1993) and others using body length*body width values (mm).

Usage

```
lengthwidthsize(BLW, Eq = "DIP")
```

Arguments

BLW	A vector of fly body length*body width measurements (mm).
Eq	a vector of a predictive allometry for Diptera, Hymenoptera or Lepidoptera. Options implemented are:

Value

A dataframe with body size, as dry weight (mg) is returned for each specimen from selected equation.

References

Kendall et al. (2018) Pollinator size and its consequences: Predictive allometry for pollinating insects. <doi:10.1101/397604>

Sample et al. (1993) Estimation of insect biomass by length and width. American Midland Naturalist, 234-240.

Examples

```
lengthwidthsize(BLW=c(3,5,2), Eq = c("Brachycera"))
```

nectarload	<i>Converts bee body length (mm) to total field nectar load (ul).</i>
------------	---

Description

Calculates total field nectar load (ul) using body length (mm) from Henry & Rodet (2008).

Usage

```
nectarload(BL)
```

Arguments

BL vector of body length measurements (mm).

Value

A dataframe with bee total field nectar load (ul) is returned for each specimen.

References

Kendall et al. (2018) Pollinator size and its consequences: Predictive allometry for pollinating insects. <doi:10.1101/397604>

Henry, M., & Rodet, G. (2018). Controlling the impact of the managed honeybee on wild bees in protected areas. *Scientific reports*, 8(1), 9308.

Examples

```
nectarload(BL=c(10,5,2))
```

pollimetry_dataset	<i>Body size and intertegular distance measurements of ~4500 pollinating insect specimens.</i>
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Description

A dataset containing the body size in dry weight (mg), intertegular distance (mm), body length (mg) and metadata for 4438 measured bee and hoverfly specimens.

Usage

```
pollimetry_dataset
```

Format

An object of class `data.frame` with 4434 rows and 25 columns.

Details

@references Kendall et al. (2018) Pollinator size and its consequences: Predictive allometry for pollinating insects. <doi:10.1101/397604>

tonguelength	<i>Converts ITD (cm) to tongue length for bees.</i>
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Description

Calculates tongue length (mm) from Cariveau et al. (2015) using intertegular distance (ITD) values (cm)..

Usage

```
tonguelength(x, mouthpart = "all")
```

Arguments

x	A dataframe with the following two columns: bee intertegular distance (IT) measurements in mm and Family, a vector of bee families. Only implemented 5 out of the extant 7 families: "Andrenidae", "Apidae", "Colletidae", "Halictidae", "Megachilidae".
mouthpart	The mouth part you are interested in. Options are "all", "glossa", "prementum" and "tongue" (i.e. gloss + prementum)

Value

A dataframe with bee tongue length (mm) and 95

References

Kendall et al. (2018) Pollinator size and its consequences: Predictive allometry for pollinating insects. <doi:10.1101/397604>

Cariveau et al. (2016) The allometry of bee tongue length and its uses in ecology and evolution. PLoS ONE 11(3): e0151482 <doi:10.1371/journal.pone.0151482>

Examples

```
example=cbind.data.frame(IT=c(1.3,2.3),
                          Family=c("Andrenidae","Apidae"))
tonguelength(example,mouthpart="all")
```

wingloading	<i>Converts intertegular distance (mm) to wing loading (mg mm²).</i>
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Description

Calculates wing loading (mg mm²) expressed as dry weight per total wing area using intertegular distance (mm) from Bullock (1999).

Usage

```
wingloading(IT)
```

Arguments

IT vector of intertegular distance measurements (mm).

Value

A dataframe with wing loading (mg mm²) is returned for each specimen.

References

Kendall et al. (2018) Pollinator size and its consequences: Predictive allometry for pollinating insects. <doi:10.1101/397604>

Bullock, S. H. (1999). Relationships among body size, wing size and mass in bees from a tropical dry forest in Mexico. *Journal of the Kansas Entomological Society*, 426-439.

Examples

```
wingloading(IT=c(10,5,2))
```

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