Hierarchical species response curves in package eHOF

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Abstract

This is an example session to show how to use enhanced hierarchical logistic regression modeling in R with package *eHOF*. Only a few possibilities and applications can be covered. Use the usual help functions for further information or contact the author if in doubt. The package is still in it's early stage. After the installation of package eHOF you can access this PDF [1] with

vignette("eHOF")

1 Preparations

```
library(eHOF)

## Lade nötiges Paket:  mgcv
## Lade nötiges Paket:  nlme
## This is mgcv 1.8-42.  For overview type 'help("mgcv-package")'.
## Lade nötiges Paket:  lattice
## This is eHOF 1.15 - build:  2024-01-28
```

1.1 Load vegetation data

Hierarchical logistic regressions can be used in many fields. We will use vegetation data and we can use package **vegdata** [Jansen and Dengler, 2010] to load vegetation data from a Turboveg [Hennekens and Schaminée, 2001] database. Taxon names can be evaluated Jansen and Dengler [2010] if they are referenced with an appropriate taxonomic reference list [Jansen and Dengler, 2008]. Within this sample session we will use the build-in vegetation dataset of package **vegdata** from the floodplain of river Elbe [Leyer and Wesche, 2007] and a dataset delivered with **eHOF** from arable land of North-Eastern Germany with measured pH.

```
library(vegdata)
db <- 'elbaue'
site <- tv.site(db)
veg <- tv.veg(db, taxval = FALSE, spcnames = 'Numbers')
obs <- tv.obs(db)
# taxa <- tax(unique(obs$TaxonUsageID), verbose=TRUE)
# write.csv2(taxa, file='taxonnames.csv')
taxa <- tax('all') # read.csv('taxonnames.csv')
names(veg) <- sub('.0', '', names(veg), fixed=TRUE)
names(veg) <- taxa$LETTERCODE[match(names(veg), taxa$TaxonUsageID)]
```

Normally you will use the capabilities of the vegdata package and the taxonomic reference list of your Turboveg installation to replace species numbers with shortletters or real names. For the sake of CRAN policy (not to download foreign data) we set tax=FALSE and replace taxnumbers manually.

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[1] Id: eHOF.Rnw processed with eHOF 1.15 in R version 4.3.2 (2023-10-31) on January 28, 2024

1.2 Cover transformation

If you want to use cover values as performance, it might be better to use cover transformed abundance values instead of the original percentage cover.

```
veg.sqrt <- tv.veg(db, cover.transform='sqrt', tax=FALSE, spcnames='Numbers')
names(veg.sqrt) <- sub('.0', '', names(veg.sqrt), fixed=TRUE)
names(veg.sqrt) <- taxa$LETTERCODE[match(names(veg.sqrt), taxa$TaxonUsageID)]
```

or even presence-absence information only.

```
veg.pa <- tv.veg(db, cover.transform='pa', tax=FALSE, spcnames='Numbers')
names(veg.pa) <- sub('.0', '', names(veg.pa), fixed=TRUE)
names(veg.pa) <- taxa$LETTERCODE[match(names(veg.pa), taxa$TaxonUsageID)]
```

2 Modeling hierarchical logistic regressions

Introduced by Ramenskij in the early 20th century and named direct gradient analysis by Whittaker [1967] is modeling species responses along environmental gradients still a frequent task in vegetation ecology. Several algorithms are available to map the performance of a species along changing ecological conditions. Often it is difficult to decide which level of complexity is needed to get an adequate simplification of the data. In 1993 Huisman, Olff and Fresco introduced a set of hierarchical models to combine the wish for simple and easy to interpret response models with the need to catch different kinds of niche types and species response data [Huisman et al., 1993].

Species responses along measured environmental gradients are cross-sections of the species hyperniche. Even if we assume, that the physiological niche of a species should be simple (e.g. unimodal or with a specific threshold) we can not expect, that realized niches should be that simple too. Nevertheless, due to the generally high number of hidden gradients in field data and the resulting unbalanced datasets, it seems to be advisable not to use a modeling technique like Generalised Additive Models (GAM) but to restrict ourselves to a more conservative set of model types which can be interpreted afterwards.

2.1 Modeltypes

Huisman, Olff and Fresco suggested five response shapes Huisman et al. [1993]. Additional to these we added two bimodal model types so that we get 7 hierarchical model types in total (see Fig. 1).

The seven models are of increasing complexity. Maybe the most important model type is number I: a flat response, that means there is no significant trend along the gradient for that species. It is our null hypothesis and ensures that only species with a clear response will be modelled with one of the further model types. Shape II is monotone sigmoidal with a top at one end of the gradient, III is monotone sigmoidal with a plateau below the maximal upper abundance value. Model type IV is the canonical form of species response, a unimodal symmetric model, V is a unimodal skewed model and model types VI and VII have two optima, VI with tops being equal.

2.2 How to use function HOF?

For all species in a vegetation data frame above a specific frequency threshold (10 by default) all six model shapes are modelled and stored in a HOF object. The most appropriate model type is evaluated only at the moment this object is printed, summarized or plotted.

```
mods <- HOF(veg, site$MGL, M=100, family = poisson, bootstrap = NULL)
```

```
mods

## Bootstrap results missing.  Using selectMethod "pick.model" instead.
```

```
data(acre)
sel <- c('ELYMREP', 'VEROPES', 'CONSREG', 'DESUSOP', 'VEROARV', 'ARTE#VU', 'ACHIMIL')
mo <- HOF(acre[match(sel, names(acre))], acre.env$PH_KCL, M=1, bootstrap=NULL)
par(mar=c(4,4,1,1)+.1)
autolayout(7)
par(mar=c(4,4,1,1)+.1)
for(i in 1:7) plot(mo[[i]], model = eHOF.modelnames[i], marginal ='n')
```
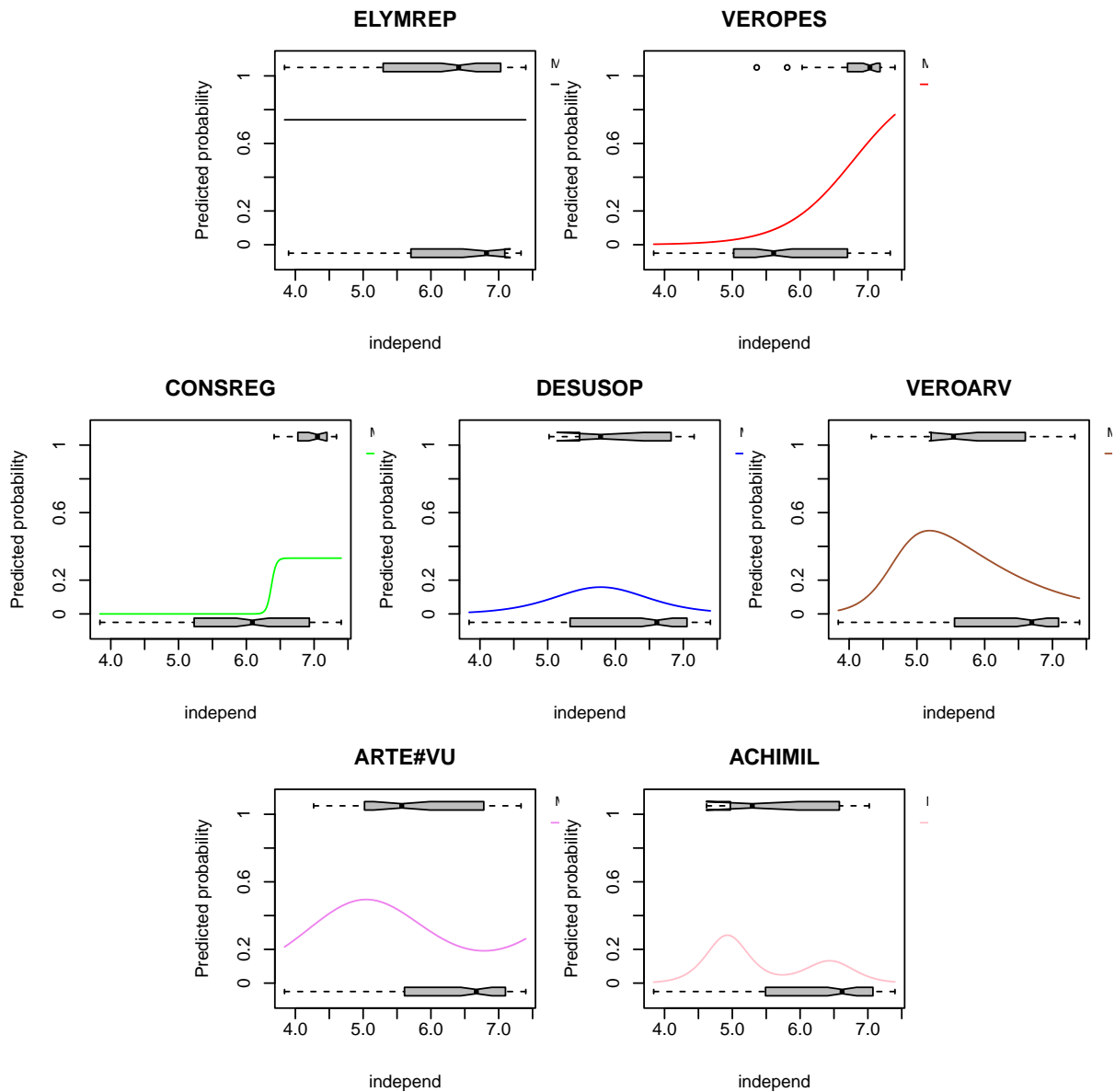

Figure 1: The layout plot shows the seven model types of enhanced Hierarchical logistic regression modeling.

```
## Deviances:
##       STLLPAL CARXTCU CARXPAG ACERPSE CRDMPRA GALMTAG POA TRI ALPCPRA PHLRARU
## I      29.824 498.281  44.733 736.321  42.574  52.425  85.751 453.553 728.928
## II     26.791 405.125  27.974 682.456  40.257  40.908  85.356 424.848 709.313
## III    21.720 308.033  19.055 376.393  37.312  32.680  73.589 276.331 648.947
## IV     15.838 218.694  22.687 250.278  27.862  30.152  61.504 209.237 658.211
## V      15.838 218.688  22.486 243.203  23.300  30.109  60.913 209.113 658.149
## VI     15.838 218.694  20.981 250.278  27.862  30.152  61.504 209.237 658.211
## VII    15.838 218.694  21.081 238.389  15.720  30.152  61.505 208.959 658.211
##       POA PAL POA AAG RNNCPEP TRXCTES
## I     641.987 268.681 630.012  26.993
## II    641.482 247.349 603.353  26.300
## III   512.485 204.857 509.846  25.451
## IV    239.364 164.189 473.560  14.901
## V     167.636 162.663 473.197  14.841
## VI    239.467 164.189 473.560  14.901
## VII   239.364 164.189 473.560  14.906
##
## Suggested best models (AICc, pick.model):
## STLLPAL CARXTCU CARXPAG ACERPSE CRDMPRA GALMTAG POA TRI ALPCPRA PHLRARU POA PAL
##      IV      IV     III     VII     VII      IV      IV     IV     III       V
## POA AAG RNNCPEP TRXCTES
##      IV      IV      IV
```

Printing the output of a HOF object with more than one species will give a matrix of deviances for all modelled species along all model types and thereafter the model type suggested as most appropriate by selected test criteria (Aikaike Information Criterion corrected for small sample size by default).

Depending on the chosen performance measure HOF modeling will lead to different species response shapes.

3   Model parameters

Restricting models to predefined shapes offers the possibility to derive ecological interpretable model characteristics like "the optimum", species niches etc. (see Fig. 4). Package eHOF contains functions to compute parameters for the different model types.

References

Stephan M. Hennekens and Johannes Hendrikus Jacques Schaminée. Turboveg, a comprehensive data base management system for vegetation datasoftware package for input, processing, and presentation of phytosociological data. *Journal of Vegetation Science*, 12:589–591, 2001.

J Huisman, H Olff, and L F M Fresco. A Hierarchical Set of Models for Species Response Analysis. *Journal of Vegetation Science*, 4(1):37–46, 1993.

Florian Jansen and Jürgen Dengler. GermanSL - eine universelle taxonomische Referenzliste für Vegetationsdatenbanken. *Tuexenia*, 28:239–253, 2008.

Florian Jansen and Jürgen Dengler. Plant names in vegetation databases - a neglected source of bias. *Journal of Vegetation Science*, 21(6):1179–1186, Aug 2010. doi: 10.1111/j.1654-1103.2010.01209.x. URL http://doi.wiley.com/10.1111/j.1654-1103.2010.01209.x.

Ilona Leyer and Karsten Wesche. *Multivariate Statistik in der Ökologie*. Springer, Berlin, 2007.

Robert Harding Whittaker. Gradient analysis of vegetation. *Biological Reviews*, 49:207–264, 1967.

```
mods.sq <- HOF(veg.sqrt, site$MGL, M=10, family= poisson, freq.limit=10, bootstrap=NULL)
plot(mods.sq)
          ## Bootselect or IC.weight method only possible after bootstrapping.
```
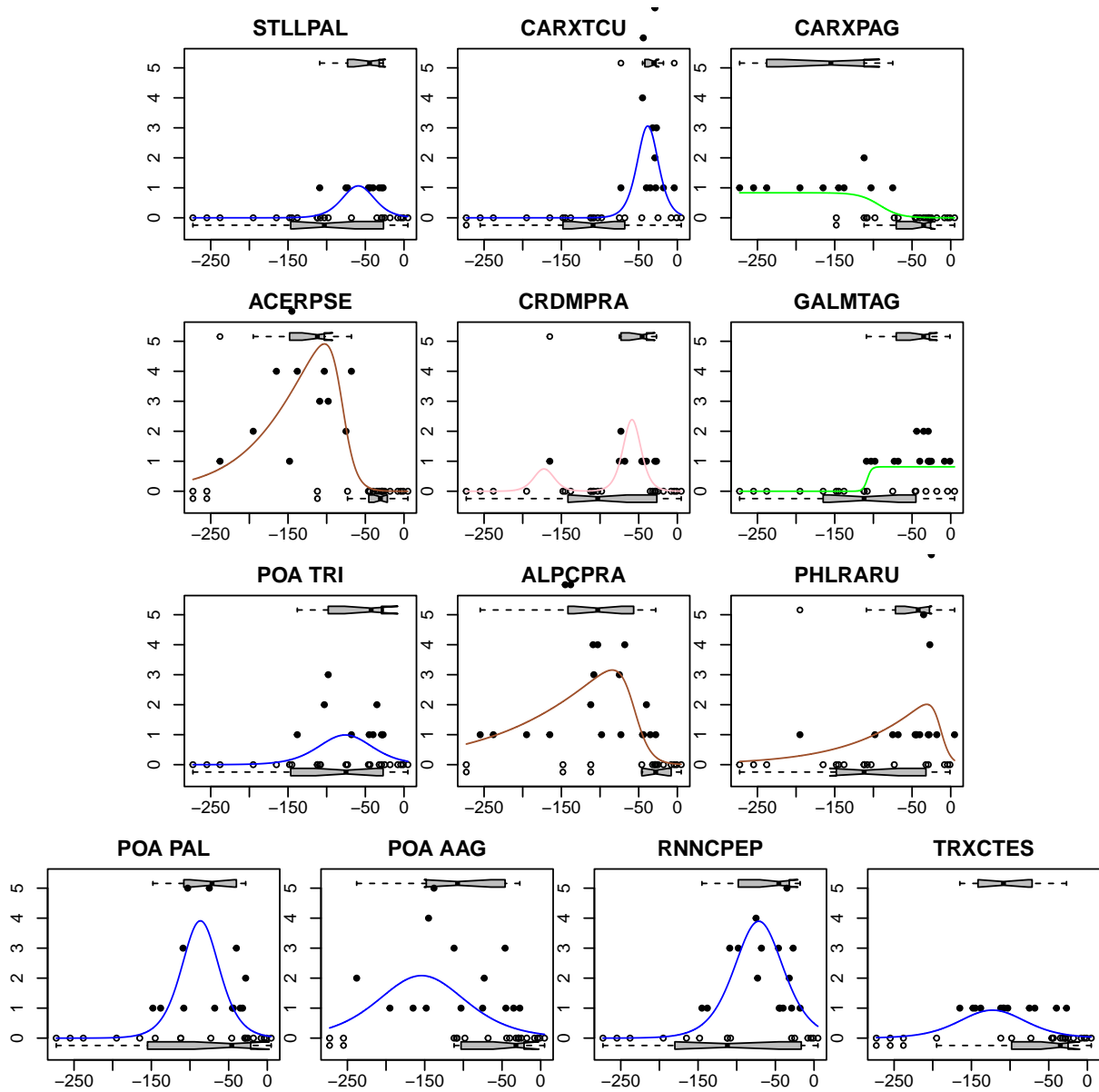

Figure 2: Most adequate model types for all species with at least 10 occurrences, square-root cover performance.

```
mods.pa <- HOF(veg.pa, site$MGL, M=1, bootstrap=NULL)
plot(mods.pa)
```
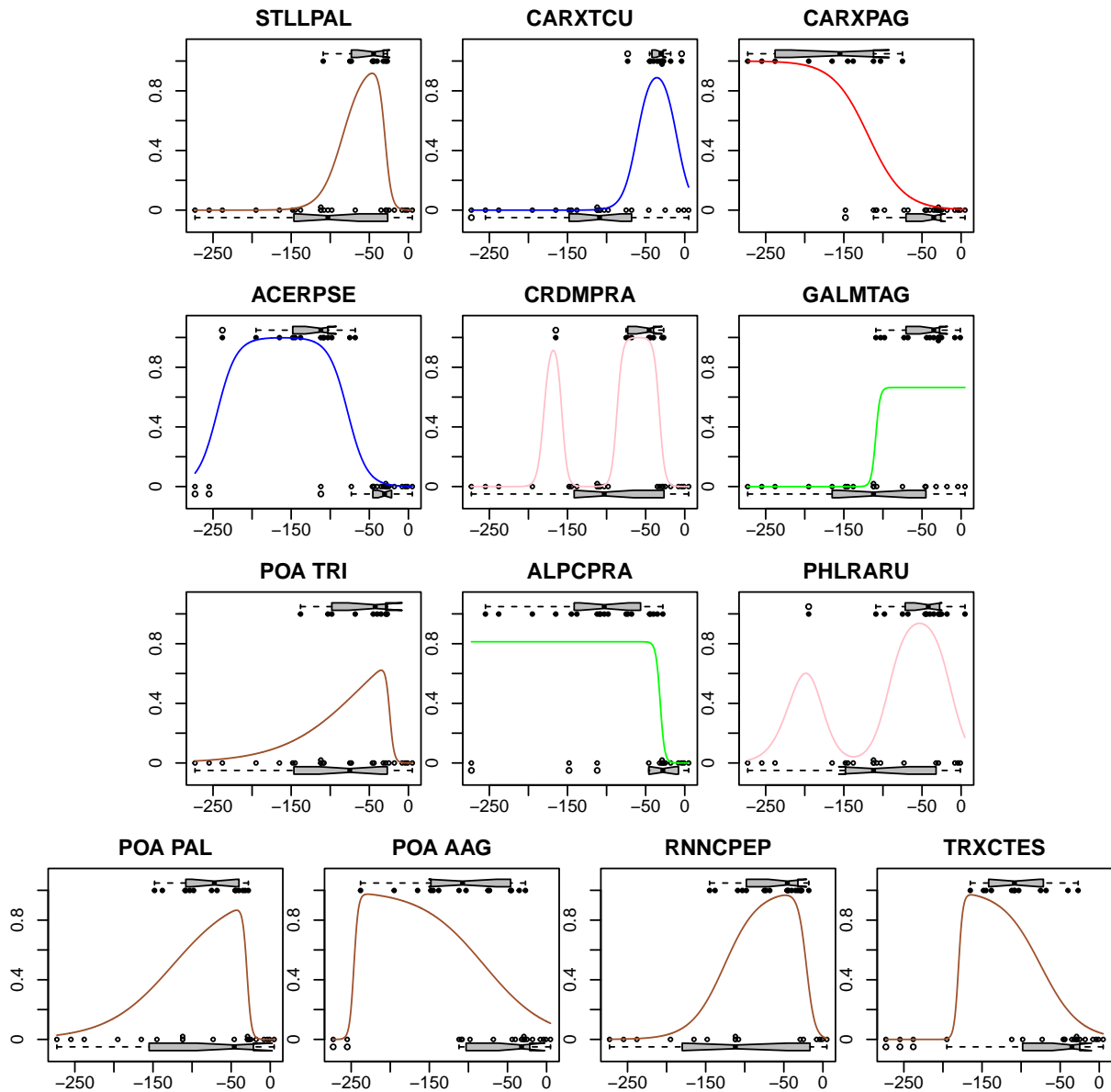

Figure 3: Most adequate model types for all species of the Elbaue dataset with at least 10 occurrences, presence-absence information.
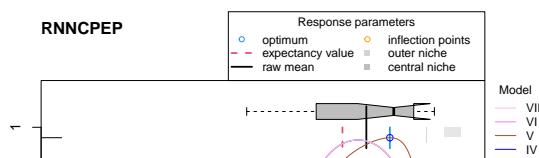
```r
lRP <- taxa$LETTERCODE[taxa$TaxonName == 'Ranunculus repens']
Para(mods.pa[[lRP]])
```

```
## $species
## [1] "RNNCPEP"
##
## $abund.sum
## [1] 18
##
## $range
## [1] -273     5
##
## $model
## [1] "V"
##
## $para
##           a           b           c           d
## -46.820044   51.692137    6.827976   12.894789
##
## $M
## [1] 1
##
## $mini
## [1] 0.001081879
##
## $pess
## [1] -272.9999
##
## $top
## [1] 0.966996
##
## $opt
## [1] -48.14773
##
## $max.slope
## [1] 12.77346
##
## $inflection
## [1] -125.79960  -21.15038
##
## $expect
## [1] -80.21819
##
## $centralBorder
##   central.low central.high
##     -23.19377     -23.19377
##
## $outerBorder
##      outer.low     outer.high
##   6.610696e-05 -1.105007e+01
##
## $raw.mean
## [1] -64.05556
##
## attr(,"class")
## [1] "Para.HOF"
```

```r
plot(mods.pa[[lRP]], para=TRUE, onlybest=FALSE)
```

RNNCPEP

Response parameters
- optimum
- expectancy value
- raw mean
- inflection points
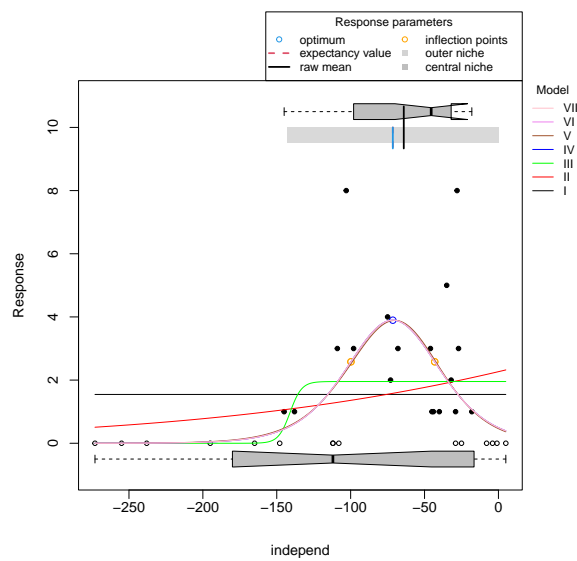- outer niche
- central niche

Model
- VII
- VI
- V
- IV

```
mod.sqrt <- eHOF:::HOF.default(veg.sqrt[[lRP]], site$MGL, M=10, family=poisson, bootstrap = 10)
plot(mod.sqrt, marginal='point', para=TRUE, onlybest=FALSE, newdata=seq(min(mod.sqrt$range), max(mod
```



```
Para(mod.sqrt)
```

Figure 5: Hierarchical logistic regression models for *Ranunculus repens* square root cover within the Elbaue dataset with plotted parameters of the most adequate model.