Pipeline_Analysis

1 Import data

Our first step is to import packages and data into R. The trait data and OMI data also need to be merged.

Load packages

```
library(ape)
library(dplyr)
library(usdm)
library(caret)
library(corrplot)
library(phylolm)
```

Import data

The datasets can be found in different GitHub repositories. The ungulate

dataset and tree can be found in the trait-organismal-ungulates repository.

The OMI data is found in the trait-geo-diverse-ungulates repository.

```
ungulatesData <- read.csv("https://raw.githubusercontent.com/naturalis/trait-organismal-ungulates/maste
omi <- read.csv("https://raw.githubusercontent.com/naturalis/trait-geo-diverse-ungulates/master/results/
tree <- read.tree("https://raw.githubusercontent.com/naturalis/trait-organismal-ungulates/master/data/u
```

Merge datasets

#The ungulate data and OMI data have to be merged into one dataset. The EoL-ID is removed and the data is merged by the canonical name (present in both the datasets). The last step is to replace the spaces in the canonical name with underscores, to match the species names in the tree.

```
ungulatesData <- ungulatesData[2:60]
names(omi)[names(omi)=="X"] <- "CanonicalName"
dataset <- merge(ungulatesData, omi, by="CanonicalName")
dataset$CanonicalName <- gsub(" ", "_", dataset$CanonicalName)
# Clean up the global environment
rm(ungulatesData, omi)
```

2 Preprocessing

Equalize species in tree and dataset

To start, 'Equus asinus' is renamed to the 'Equus africanus' in the tree, to match the dataset. The species that aren't in the tree are dropped from the dataset. The species that aren't in the dataset are dropped from the tree.

```
# Changed Equus asinus to Equus africanus in the tree
tree$tip.label[tree$tip.label=="Equus_asinus"] <- "Equus_africanus"
# Check Which species aren't in the tree
dropRows <- setdiff(dataset$CanonicalName, tree$tip.label)
# Drop rows that aren't in the tree (check manually if these are domesticated)
row.names(dataset) <- dataset$CanonicalName
dataset <- dataset[!(row.names(dataset) %in% dropRows), ]
# Drop tips that aren't in dataset
dropTips <- setdiff(tree$tip.label, dataset$CanonicalName)
tree <- drop.tip(tree, dropTips)
# Final check to see if there are any differences
setdiff(dataset$CanonicalName, tree$tip.label)
```

```
## character(0)
```

```
setdiff(tree$tip.label, dataset$CanonicalName)
```

```
## character(0)
```

```
rm(dropRows, dropTips)
```

Miscellaneous preprocessing

#The dots in the column names are replaced with underscores. After that, the #traits that consist of more than 100 missing values, traits that have no #information gain and traits that are almost identical to other traits are #removed.

```r
# Rename columns with dots in the name
names(dataset)[names(dataset)=="Horns.Antlers"] <- "Horns_Antlers"
names(dataset)[names(dataset)=="X21.1_PopulationDensity_n.km2"] <- "X21.1_PopulationDensity_n_km2"
# Remove traits that (almost) only consist of missing values (>100 NA)
dataset <- subset(dataset, select = -c(X5.4_WeaningBodyMass_g, X13.3_WeaningHeadBodyLen_mm, X13.2_Neona
# Remove traits without any information gain (only consist of one value)
dataset <- subset(dataset, select = -c(Motility, ParentalCare, X12.2_Terrestriality))
# Remove traits that are almost identical to other traits
dataset <- subset(dataset, select = -c(PullStrength, NumOffspring, BreedingInterval,
                                       Diet, AVGWeight, MaturityReachFemale, MaturityReachMale,
                                       X22.2_HomeRange_Indiv_km2, X5.3_NeonateBodyMass_g,
                                       X16.1_LittersPerYear,X7.1_DispersalAge_d))
```

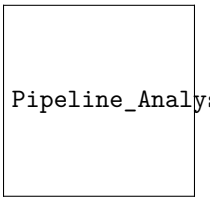
3 VIF-analysis

There is probably collinearity present amongst the traits in the dataset. Collinearity can lead to bias in the model, so we must correct for this. This can be done by running a variable inflation factor analysis (VIF).

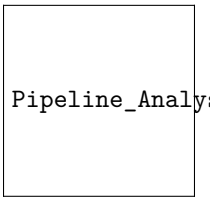
The VIF.R script contains the whole VIF analysis. The R script is sourced below. This script only requires the 'dataset' variable and after it is run, it will output the 'predictors' variable.

```r
source("VIF.R")
```

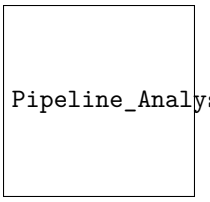
```
## The first correlation matrix is a visualization of the dataset without the removal of any traits. Th
```




```
## The second corrplot is a visualization of the dataset after cutoff values are implemented and adultb
```




```
## The third correlation matrix is our final product after removing all highly correlated traits.
```



4 Model Selection

A Generalized Linear Model (GLM) must be made. The Domestication column is

used as the dependent variable, and the other columns are the predictor

#variables. For the model selection the phylolm package and phyloglmstep function #are required.

```
source("ModelSelection.R")
```

```
## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(formula, data, phy, method, btol, log.alpha.bound, start.beta, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(formula, data, phy, method, btol, log.alpha.bound, start.beta, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(formula, data, phy, method, btol, log.alpha.bound, start.beta, : phyloglm failed

## ----------
## Starting model: Domestication ~ 1
## Direction: forward
## AIC(k=2): 56.6106524764285

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g
##  AIC(k=2): 57.9934515575065
##  Proposed: Domestication ~ 1 + X1.1_ActivityCycle
##  AIC(k=2): 53.92577186747
##  Proposed: Domestication ~ 1 + X15.1_LitterSize
##  AIC(k=2): 54.5455038079369

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.
```

```
##  Proposed: Domestication ~ 1 + X21.1_PopulationDensity_n_km2
##  AIC(k=2): 63.1729237722212

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + X10.2_SocialGrpSize
##  AIC(k=2): 56.0777898024262
##  Proposed: Domestication ~ 1 + Sociality
##  AIC(k=2): 55.4033096572127
##  Proposed: Domestication ~ 1 + SocialHierarchy
##  AIC(k=2): 57.6894768694598
##  Proposed: Domestication ~ 1 + MatingSystem
##  AIC(k=2): 57.9421070595856
##  Proposed: Domestication ~ 1 + YearRoundBreeding
##  AIC(k=2): 58.0280171685188
##  Proposed: Domestication ~ 1 + DevelopmentStrategy
##  AIC(k=2): 56.327118233051
##  Proposed: Domestication ~ 1 + Horns_Antlers
##  AIC(k=2): 45.613584212066

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + Lifespan
##  AIC(k=2): 57.037186986092
##  Proposed: Domestication ~ 1 + NaturalPredators
##  AIC(k=2): 56.1629506273111

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + AVGMovingSpeed
##  AIC(k=2): 54.5441670071874

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated c
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + AVGTravelDistance
##  AIC(k=2): 67.9974137437575
##  Proposed: Domestication ~ 1 + Aspect
##  AIC(k=2): 57.8731049688643
##  Proposed: Domestication ~ 1 + ClayPercentage
```

```
##  AIC(k=2): 57.6960556418477
##  Proposed: Domestication ~ 1 + PETWettestQuarter
##  AIC(k=2): 56.4819056048058
##  Proposed: Domestication ~ 1 + OrganicCarbon
##  AIC(k=2): 57.7619101766404
## ----------
## Step 1
## Current model: Domestication ~ 1 + Horns_Antlers
## AIC(k=2): 45.613584212066

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + Horns_Antlers
##  AIC(k=2): 48.1376619146629
##  Proposed: Domestication ~ 1 + X1.1_ActivityCycle + Horns_Antlers
##  AIC(k=2): 45.7121668826111
##  Proposed: Domestication ~ 1 + X15.1_LitterSize + Horns_Antlers
##  AIC(k=2): 47.6358320512138

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + X21.1_PopulationDensity_n_km2 + Horns_Antlers
##  AIC(k=2): 45.9553767938408

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X10.2_SocialGrpSize + Horns_Antlers
##  AIC(k=2): 52.3592504762737
##  Proposed: Domestication ~ 1 + Sociality + Horns_Antlers
##  AIC(k=2): 47.3648539771112
##  Proposed: Domestication ~ 1 + SocialHierarchy + Horns_Antlers
##  AIC(k=2): 47.3198790366941
##  Proposed: Domestication ~ 1 + MatingSystem + Horns_Antlers
##  AIC(k=2): 47.6352540636869
##  Proposed: Domestication ~ 1 + YearRoundBreeding + Horns_Antlers
##  AIC(k=2): 47.504233445909
##  Proposed: Domestication ~ 1 + DevelopmentStrategy + Horns_Antlers
##  AIC(k=2): 42.3493668148517

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + Horns_Antlers + Lifespan
##  AIC(k=2): 47.0975460988458
##  Proposed: Domestication ~ 1 + Horns_Antlers + NaturalPredators
##  AIC(k=2): 45.1739624200389
```

```
## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 41.6991240391468

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + Horns_Antlers + AVGTravelDistance
##  AIC(k=2): 49.6237000824552
##  Proposed: Domestication ~ 1 + Horns_Antlers + Aspect
##  AIC(k=2): 47.0907033499053
##  Proposed: Domestication ~ 1 + Horns_Antlers + ClayPercentage
##  AIC(k=2): 47.9834923857749
##  Proposed: Domestication ~ 1 + Horns_Antlers + PETWettestQuarter
##  AIC(k=2): 45.2460513719232
##  Proposed: Domestication ~ 1 + Horns_Antlers + OrganicCarbon
##  AIC(k=2): 47.3827735459608
## ----------
## Step 2
## Current model: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed
## AIC(k=2): 41.6991240391468

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 41.6567554371193

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + X1.1_ActivityCycle + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 42.925823394066

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + X15.1_LitterSize + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 43.7829086829079

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + X21.1_PopulationDensity_n_km2 + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 43.129859503875
```

```
## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X10.2_SocialGrpSize + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 43.4050412894731

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + Sociality + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 43.0647807302713

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + SocialHierarchy + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 41.5328469787189

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + MatingSystem + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 43.5254916908653

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + YearRoundBreeding + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 43.0289757642901

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + DevelopmentStrategy + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 40.0816744002034

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + Horns_Antlers + Lifespan + AVGMovingSpeed
##  AIC(k=2): 42.7807402253454

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + Horns_Antlers + NaturalPredators + AVGMovingSpeed
##  AIC(k=2): 41.2272585933605
```

```
## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed + AVGTravelDistance
##  AIC(k=2): 33.7709623835929

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed + Aspect
##  AIC(k=2): 43.7474845854765

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed + ClayPercentage
##  AIC(k=2): 44.3599411768702

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed + PETWettestQuarter
##  AIC(k=2): 43.1430718858271

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed + OrganicCarbon
##  AIC(k=2): 43.472668851961
## ----------
## Step 3
## Current model: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed + AVGTravelDistance
## AIC(k=2): 33.7709623835929

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + Horns_Antlers + AVGMovingSpeed + AVGTravelDista
##  AIC(k=2): 34.0271621881177

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X1.1_ActivityCycle + Horns_Antlers + AVGMovingSpeed + AVGTravelDistanc
##  AIC(k=2): 35.7290077698583
```

```
## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X15.1_LitterSize + Horns_Antlers + AVGMovingSpeed + AVGTravelDistance
##  AIC(k=2): 34.3862472411106

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + X21.1_PopulationDensity_n_km2 + Horns_Antlers + AVGMovingSpeed + AVGTr
##  AIC(k=2): 35.8466802152485

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X10.2_SocialGrpSize + Horns_Antlers + AVGMovingSpeed + AVGTravelDistar
##  AIC(k=2): 34.3373300073387

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + Sociality + Horns_Antlers + AVGMovingSpeed + AVGTravelDistance
##  AIC(k=2): 73.9974137437575

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + SocialHierarchy + Horns_Antlers + AVGMovingSpeed + AVGTravelDistance
##  AIC(k=2): 35.2414196511258

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + MatingSystem + Horns_Antlers + AVGMovingSpeed + AVGTravelDistance
##  AIC(k=2): 38.3855370375528
```

```
## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + YearRoundBreeding + Horns_Antlers + AVGMovingSpeed + AVGTravelDistanc
##  AIC(k=2): 35.0518743755631

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + DevelopmentStrategy + Horns_Antlers + AVGMovingSpeed + AVGTravelDistar
##  AIC(k=2): 32.3677614267966

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + Horns_Antlers + Lifespan + AVGMovingSpeed + AVGTravelDistance
##  AIC(k=2): 33.5858649461794

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + Horns_Antlers + NaturalPredators + AVGMovingSpeed + AVGTravelDistance
##  AIC(k=2): 35.2819730539422

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed + AVGTravelDistance + Aspect
##  AIC(k=2): 35.9947925721223

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed + AVGTravelDistance + ClayPercentage
##  AIC(k=2): 35.3106321472077

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed + AVGTravelDistance + PETWettestQuarte
##  AIC(k=2): 35.4218971397666
```

```
## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + Horns_Antlers + AVGMovingSpeed + AVGTravelDistance + OrganicCarbon
##  AIC(k=2): 35.4102013806564
## ----------
## Step 4
## Current model: Domestication ~ 1 + DevelopmentStrategy + Horns_Antlers + AVGMovingSpeed + AVGTravelD
## AIC(k=2): 32.3677614267966

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + DevelopmentStrategy + Horns_Antlers + AVGMovin
##  AIC(k=2): 28.3458557864183

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X1.1_ActivityCycle + DevelopmentStrategy + Horns_Antlers + AVGMovingS
##  AIC(k=2): 34.310713026814

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X15.1_LitterSize + DevelopmentStrategy + Horns_Antlers + AVGMovingSpe
##  AIC(k=2): 33.5990598651266

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X21.1_PopulationDensity_n_km2 + DevelopmentStrategy + Horns_Antlers +
##  AIC(k=2): 34.2481180478605

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed
```

```
##  Proposed: Domestication ~ 1 + X10.2_SocialGrpSize + DevelopmentStrategy + Horns_Antlers + AVGMovingS
##  AIC(k=2): 33.2669674265561

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + Sociality + DevelopmentStrategy + Horns_Antlers + AVGMovingSpeed + AVG
##  AIC(k=2): 75.9974137437575

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + SocialHierarchy + DevelopmentStrategy + Horns_Antlers + AVGMovingSpeed
##  AIC(k=2): 75.9974137437575

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + MatingSystem + DevelopmentStrategy + Horns_Antlers + AVGMovingSpeed +
##  AIC(k=2): 33.4157251299152

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + YearRoundBreeding + DevelopmentStrategy + Horns_Antlers + AVGMovingSpe
##  AIC(k=2): 34.470192591438

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.
```

```
## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + DevelopmentStrategy + Horns_Antlers + Lifespan + AVGMovingSpeed + AVG
##  AIC(k=2): 31.4277907883741

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + DevelopmentStrategy + Horns_Antlers + NaturalPredators + AVGMovingSpee
##  AIC(k=2): 75.9974137437575

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + DevelopmentStrategy + Horns_Antlers + AVGMovingSpeed + AVGTravelDistan
##  AIC(k=2): 32.7899841157771

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + DevelopmentStrategy + Horns_Antlers + AVGMovingSpeed + AVGTravelDistan
##  AIC(k=2): 34.4076812039382

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + DevelopmentStrategy + Horns_Antlers + AVGMovingSpeed + AVGTravelDistan
##  AIC(k=2): 34.2606588651553

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

##  Proposed: Domestication ~ 1 + DevelopmentStrategy + Horns_Antlers + AVGMovingSpeed + AVGTravelDistan
##  AIC(k=2): 34.3686856858303
## ----------
## Step 5
## Current model: Domestication ~ 1 + X5.1_AdultBodyMass_g + DevelopmentStrategy + Horns_Antlers + AVGMo
## AIC(k=2): 28.3458557864183
```

```
## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + X1.1_ActivityCycle + DevelopmentStrategy + Horn
##  AIC(k=2): 30.237821037244

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + X15.1_LitterSize + DevelopmentStrategy + Horns_
##  AIC(k=2): 77.9974137437575

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + X21.1_PopulationDensity_n_km2 + DevelopmentStra
##  AIC(k=2): 29.9863970253953

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + X10.2_SocialGrpSize + DevelopmentStrategy + Hor
##  AIC(k=2): 30.4174865853183

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + Sociality + DevelopmentStrategy + Horns_Antlers
##  AIC(k=2): 77.9974137437575
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + SocialHierarchy + DevelopmentStrategy + Horns_A
##  AIC(k=2): 77.9974137437575

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + MatingSystem + DevelopmentStrategy + Horns_Antl
##  AIC(k=2): 77.9974137437575

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + YearRoundBreeding + DevelopmentStrategy + Horns
##  AIC(k=2): 77.9974137437575

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed
```

```
##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + DevelopmentStrategy + Horns_Antlers + Lifespan
##  AIC(k=2): 29.9802985618214

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + DevelopmentStrategy + Horns_Antlers + NaturalPr
##  AIC(k=2): 77.9974137437575

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + DevelopmentStrategy + Horns_Antlers + AVGMoving
##  AIC(k=2): 28.6466061442759

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + DevelopmentStrategy + Horns_Antlers + AVGMoving
##  AIC(k=2): 77.9974137437575

## Warning: glm.fit: algorithm did not converge

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```
## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : The estimated co
##   to some linear predictors beyond 'btol'. Increase btol?
##   Starting from beta=0 other than intercept.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + DevelopmentStrategy + Horns_Antlers + AVGMoving
##  AIC(k=2): 77.9974137437575

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : the boundary of
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(create.formula(plm), data, phy, method, btol, log.alpha.bound, : phyloglm failed

##  Proposed: Domestication ~ 1 + X5.1_AdultBodyMass_g + DevelopmentStrategy + Horns_Antlers + AVGMoving
##  AIC(k=2): 29.9581422264002
## ----------
## Step 6
## Current model: Domestication ~ 1 + X5.1_AdultBodyMass_g + DevelopmentStrategy + Horns_Antlers + AVGMo
## AIC(k=2): 28.3458557864183
## ---END
```

5 Modelling analysis

WIP

#The phylogenetic generalized linear modelling analysis optimizes the model. The #function phyloglm from the phylolm package is used for this.

```
# Converting dependent variable to binary state
# Domesticated = 1, wild = 0
dataset$Domestication[dataset$Domestication==2] <- 0
# Construct model
GLM <- phyloglm(formula = finalFormula, data = dataset, phy = tree, method = "logistic_MPLE", btol = 36
```

```
## Warning in phyloglm(formula = finalFormula, data = dataset, phy = tree, : will
## drop from the tree 92 taxa with missing data

## Warning in phyloglm(formula = finalFormula, data = dataset, phy = tree, : the boundary of the linear
## You can increase this bound by increasing 'btol'.

## Warning in phyloglm(formula = finalFormula, data = dataset, phy = tree, : phyloglm failed to converge
```

```r
summary(GLM)
```

```
##
## Call:
## phyloglm(formula = finalFormula, data = dataset, phy = tree,
##     method = "logistic_MPLE", btol = 36.7462, log.alpha.bound = 4)
##        AIC     logLik Pen.logLik
##      36.67     -11.33      10.33
##
## Method: logistic_MPLE
## Mean tip height: 87.3
## Parameter estimate(s):
## alpha: 0.01145475
##
## Coefficients:
##                          Estimate      StdErr z.value  p.value
## (Intercept)          -9.3504e+00  5.1361e+00 -1.8205 0.068682 .
## X5.1_AdultBodyMass_g  4.5743e-06  2.0387e-06  2.2437 0.024850 *
## DevelopmentStrategy   1.9877e+00  1.1964e+00  1.6613 0.096653 .
## Horns_Antlers         4.9891e+00  1.8994e+00  2.6267 0.008621 **
## AVGMovingSpeed       -2.3898e-01  9.5073e-02 -2.5137 0.011948 *
## AVGTravelDistance     4.6891e-03  3.3020e-03  1.4201 0.155588
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Note: Wald-type p-values for coefficients, conditional on alpha=0.01145475
```

```r
#Significant variables (those with p values <.05 include AdultBodyMass, Horns_Antlers, and avg moving s
```