

5. Imputation of missing values

Fay

2022-10-05

Load libraries

```
library(mice)

##
## Attaching package: 'mice'
## The following object is masked from 'package:stats':
##   filter
## The following objects are masked from 'package:base':
##   cbind, rbind
library(tidyr)
library(tidyverse)

## -- Attaching packages ----- tidyverse 1.3.2 --
## v ggplot2 3.3.6     v dplyr    1.0.10
## v tibble   3.1.8     v stringr  1.4.1
## v readr    2.1.3     vforcats  0.5.2
## v purrr   0.3.4
## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks mice::filter(), stats::filter()
## x dplyr::lag()   masks stats::lag()

library(VIM)

## Loading required package: colorspace
## Loading required package: grid
## VIM is ready to use.
##
## Suggestions and bug-reports can be submitted at: https://github.com/statistikat/VIM/issues
##
## Attaching package: 'VIM'
##
## The following object is masked from 'package:datasets':
##   sleep
library(fitdistrplus)

## Loading required package: MASS
```

```

## 
## Attaching package: 'MASS'
##
## The following object is masked from 'package:dplyr':
##       select
##
## Loading required package: survival
library(fitur)

## 
## Attaching package: 'fitur'
##
## The following object is masked from 'package:purrr':
##       rdnunif
library(visdat)

```

Import data

```

hm <- read.csv("output_data/MICE.csv")

# Vectors for selecting genes

#Lab genes
# The measurements of IL.12 and IRG6 are done with an other assay and will
#ignore for now
Gene_lab   <- c("IFNy", "CXCR3", "IL.6", "IL.13", "IL.10",
              "IL1RN", "CASP1", "CXCL9", "IDO1", "IRGM1", "MPO",
              "MUC2", "MUC5AC", "MYD88", "NCR1", "PRF1", "RETNLB", "SOCS1",
              "TICAM1", "TNF") # "IL.12", "IRG6")

Genes_wild  <- c("IFNy", "CXCR3", "IL.6", "IL.13", "IL.10",
                 "IL1RN", "CASP1", "CXCL9", "IDO1", "IRGM1", "MPO",
                 "MUC2", "MUC5AC", "MYD88", "NCR1", "PRF1", "RETNLB", "SOCS1",
                 "TICAM1", "TNF") #, "IL.12", "IRG6")

Facs_lab <- c("CD4", "Treg", "Div_Treg", "Treg17", "Th1",
              "Div_Th1", "Th17", "Div_Th17", "CD8", "Act_CD8",
              "Div_Act_CD8", "IFNy_CD4", "IFNy_CD8", "Treg_prop",
              "IL17A_CD4")

Facs_wild <- c( "Treg", "CD4", "Treg17", "Th1", "Th17", "CD8",
                "Act_CD8", "IFNy_CD4", "IL17A_CD4", "IFNy_CD8")

```

How do the variables look like?

1. cleaning

```

#how many nas in each column
#sapply(hm, function(x) sum(is.na(x)))

```

```
# Required step for the further imputations
hm <- hm %>% mutate_if(is.character, as.factor)
hm <- hm %>% mutate_if(is.integer, as.numeric)
```

Test different distributions

After talking with Dan and some reading, I found out that many machine learning models / packages require data following a normal distribution. I am hear trying to standardize my data to a normal distribution. After testing the MICE package on my standardized and on the raw data, I realized there was no difference in my end results.

I would like to further question if normalization / scaling of the data is necessary.

I am here using the laboratory infections, as we have more measures and I am randomly selecting a variable to represent the facs measures and another gene for the gene expression data. In some papers it is mentioned that facs / genes may each follow different distribution (adding to my confusion).

```
# I am here selecting CD4 to represent the facs dattta
facs_variable <- hm %>%
  filter(origin == "Lab", dpi == max_dpi, infection == "challenge") %>%
  dplyr::select(CD4)

# we don't want any nas as these will disrupt the distribution tests by different
# packages
facs_variable <- facs_variable %>% drop_na()

#here is our facs variabls
a <- facs_variable$CD4

# gene_variable, another random gene (MYD88), chosen due to abundancy in measures
gene_variable <- hm %>%
  filter(origin == "Lab", dpi == max_dpi, infection == "challenge") %>%
  dplyr::select(MYD88)

# Let's drop the nas again
gene_variable <- gene_variable %>%
  drop_na()

#s and hurray here is our gene variable
b <- gene_variable$MYD88
```

Fucntions to test distributions

I think I got these from Alice's package ParasiteLoad (Have to check again)

```
# Define function to be used to test, get the log lik and aic
tryDistrib <- function(x, distrib){
  # deals with fitdistr error:
  fit <- tryCatch(MASS:::fitdistr(x, distrib), error=function(err) "fit failed")
  return(list(fit = fit,
             loglik = tryCatch(fit$loglik, error=function(err) "no loglik computed"),
             AIC = tryCatch(fit$aic, error=function(err) "no aic computed")))
}
```

```

findGoodDist <- function(x, distribs, distribs2){
  l =lapply(distribs, function(i) tryDistrib(x, i))
  names(l) <- distribs
  print(l)
  listDistr <- lapply(distribs2, function(i){
    if (i %in% "t"){
      fitdistrplus::fitdist(x, i, start = list(df =2))
    } else {
      fitdistrplus::fitdist(x,i)
    }
  })
  par(mfrow=c(2,2))
  denscomp(listDistr, legendtext=distribs2)
  cdfcomp(listDistr, legendtext=distribs2)
  qqcomp(listDistr, legendtext=distribs2)
  ppcomp(listDistr, legendtext=distribs2)
  par(mfrow=c(1,1))
}

```

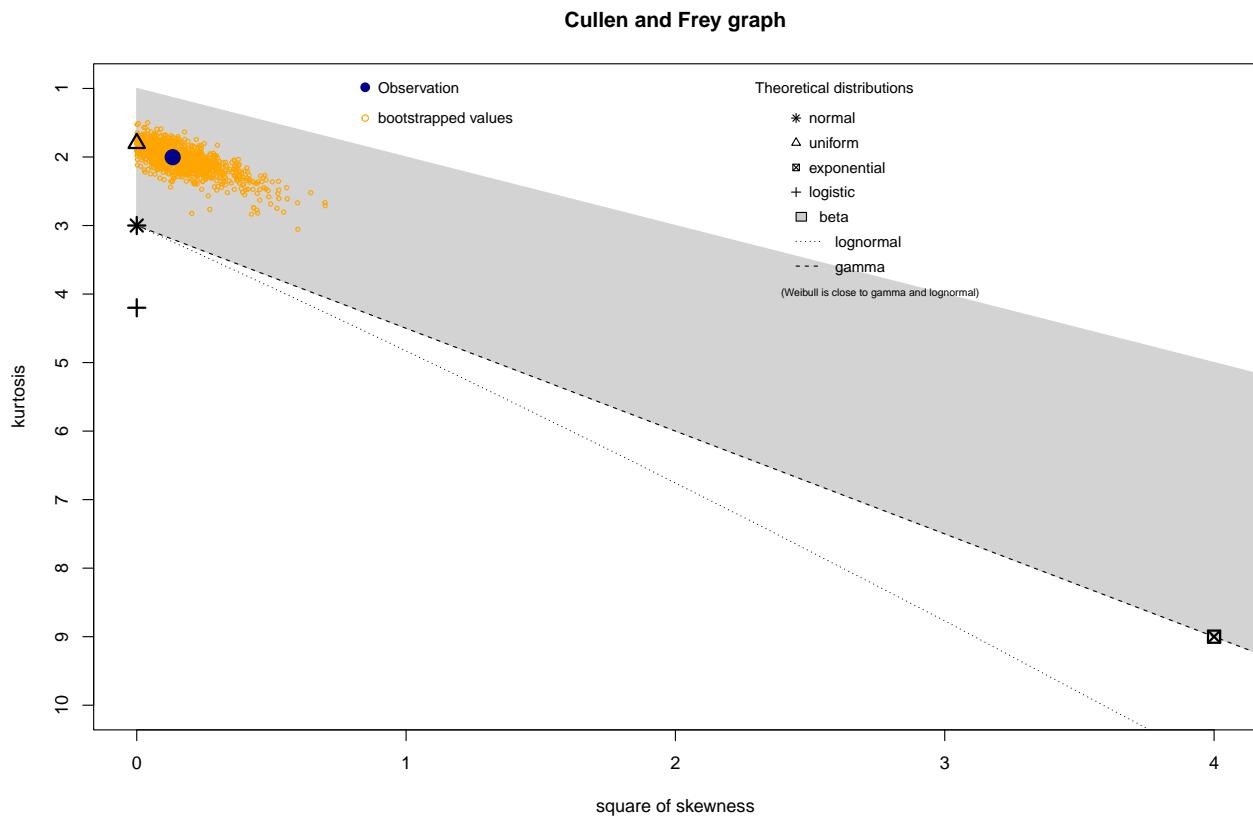
For the facs data

Testing our CD4s distributions

```

set.seed(333)
descdist(data = a, discrete = FALSE, boot = 1000)

```



```

## -----
## min: 12.3   max: 68.01
## median: 44.3
## mean: 39.87056
## estimated sd: 15.10846
## estimated skewness: -0.3653128
## estimated kurtosis: 2.003008

```

So seeing this graph, I understand we could be having a beta distribution.. But what happens next, shows something different.

Interface for looking at distributions

```
#fitur::fit_dist_addin()
```

According to interface, I can visually identify a cauchy distribution.

```
tryDistrib(a, "normal") #yes
```

```

## $fit
##      mean          sd
##  39.8705556  15.0437591
##  ( 1.3907960) ( 0.9834413)
##
## $loglik
## [1] -483.1985
##
## $AIC
## NULL

```

```
tryDistrib(a, "binomial") #nope
```

```

## $fit
## [1] "fit failed"
##
## $loglik
## [1] "no loglik computed"
##
## $AIC
## [1] "no aic computed"

```

```
tryDistrib(a, "student") #nope
```

```

## $fit
## [1] "fit failed"
##
## $loglik
## [1] "no loglik computed"
##
## $AIC
## [1] "no aic computed"

```

```
tryDistrib(a, "weibull") #yes
```

```

## $fit
##      shape          scale
##  3.026572  44.731966
##  ( 0.235684) ( 1.430370)
##

```

```

## $loglik
## [1] -481.6586
##
## $AIC
## NULL
tryDistrib(a, "weibullshifted") #nope

## $fit
## [1] "fit failed"
##
## $loglik
## [1] "no loglik computed"
##
## $AIC
## [1] "no aic computed"
tryDistrib(a, "gamma") #nope

## Warning in densfun(x, parm[1], parm[2], ...): NaNs produced

## Warning in densfun(x, parm[1], parm[2], ...): NaNs produced

## $fit
##      shape      rate
## 5.48687051 0.13761675
## (0.69652903) (0.01829378)
##
## $loglik
## [1] -490.2143
##
## $AIC
## NULL
tryDistrib(a, "cauchy") #yes

## $fit
##      location      scale
## 45.483672    9.183808
## ( 1.402233) ( 1.206321)
##
## $loglik
## [1] -510.3078
##
## $AIC
## NULL
tryDistrib(a, "exp") #nope

## $fit
## [1] "fit failed"
##
## $loglik
## [1] "no loglik computed"
##
## $AIC
## [1] "no aic computed"

```

```
tryDistrib(a, "log") #nope

## $fit
## [1] "fit failed"
##
## $loglik
## [1] "no loglik computed"
##
## $AIC
## [1] "no aic computed"
tryDistrib(a, "t")

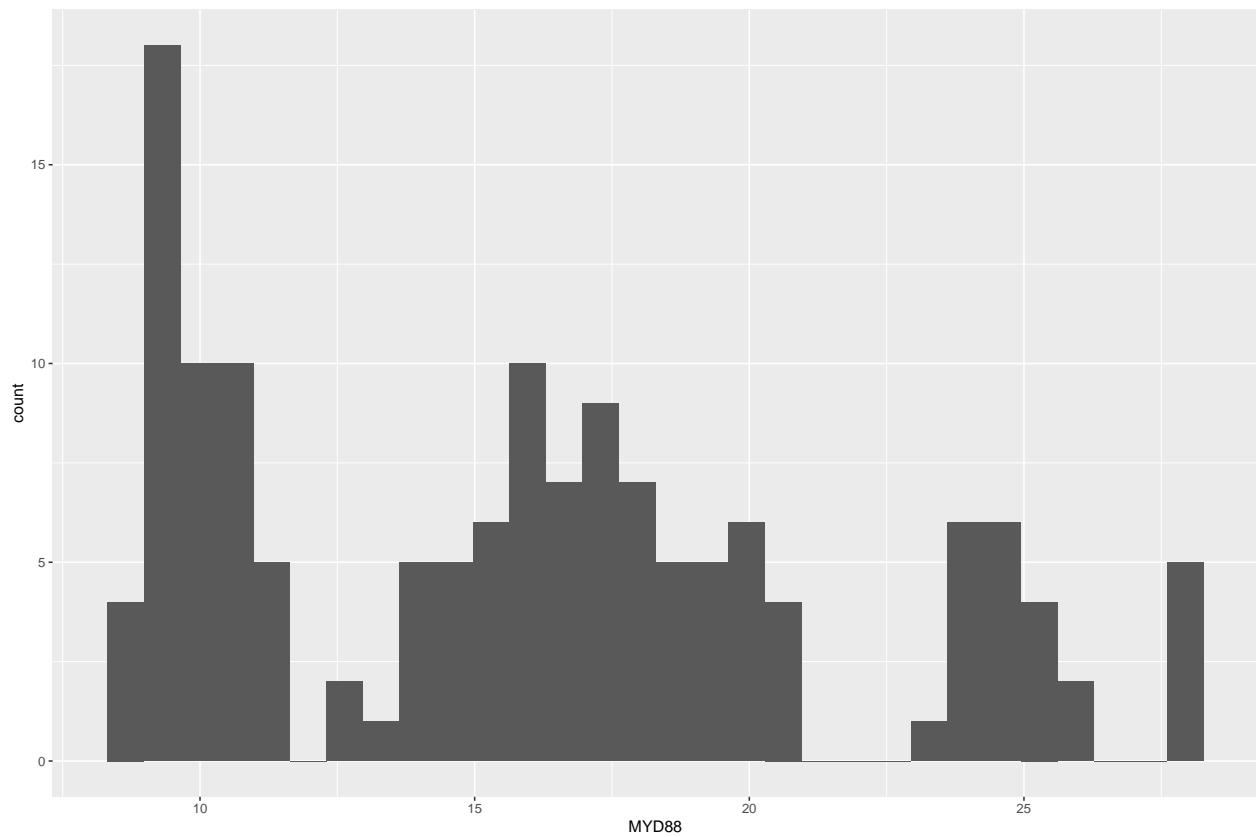
## $fit
## [1] "fit failed"
##
## $loglik
## [1] "no loglik computed"
##
## $AIC
## [1] "no aic computed"

FACS data -> cauchy?

Gene data

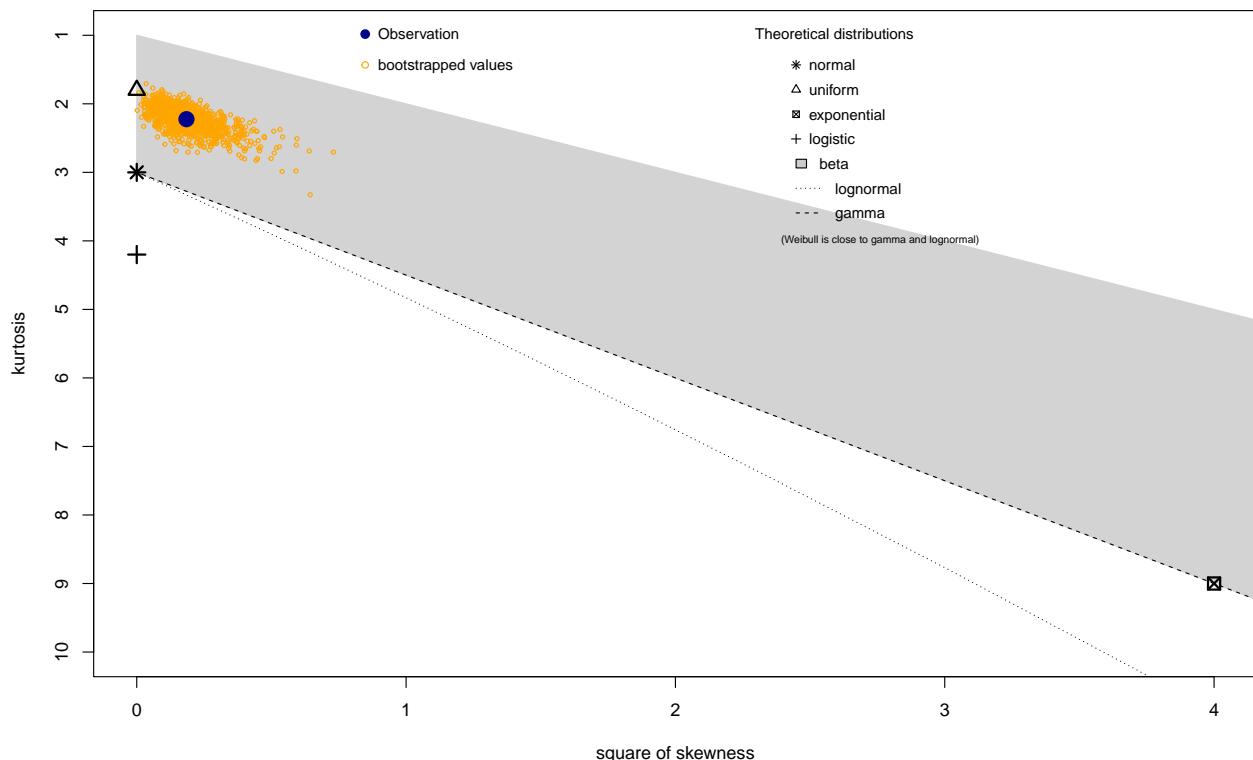
ggplot(gene_variable, aes(MYD88)) +
  geom_histogram()

## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



```
set.seed(66)
descdist(data = b, discrete = FALSE, boot = 1000)
```

Cullen and Frey graph



```
## summary statistics
## -----
## min: 8.790171 max: 28.07896
## median: 15.88865
## mean: 16.06125
## estimated sd: 5.471353
## estimated skewness: 0.4296881
## estimated kurtosis: 2.224176
```

Interface for looking at the distributions. #really cool

```
#fitur::fit_dist_addin()
```

For the gene data

```
tryDistrib(b, "normal") #yes

## $fit
##      mean          sd
##    16.0612546   5.4521888
##  ( 0.4559349) ( 0.3223947)
##
## $loglik
## [1] -445.4387
##
## $AIC
## NULL
```

```

tryDistrib(b, "binomial") #nope

## $fit
## [1] "fit failed"
##
## $loglik
## [1] "no loglik computed"
##
## $AIC
## [1] "no aic computed"
tryDistrib(b, "student") #nope

## $fit
## [1] "fit failed"
##
## $loglik
## [1] "no loglik computed"
##
## $AIC
## [1] "no aic computed"
tryDistrib(b, "weibull") #yes

## Warning in densfun(x, parm[1], parm[2], ...): NaNs produced

## $fit
##      shape      scale
## 3.2070620 17.9702182
## ( 0.2062014) ( 0.4960698)
##
## $loglik
## [1] -443.3646
##
## $AIC
## NULL

tryDistrib(b, "weibullshifted") #nope

## $fit
## [1] "fit failed"
##
## $loglik
## [1] "no loglik computed"
##
## $AIC
## [1] "no aic computed"
tryDistrib(b, "gamma") #yes

## $fit
##      shape      rate
## 8.70300403 0.54186345
## (1.01010105) (0.06473885)
##
## $loglik
## [1] -439.5963

```

```

##  

## $AIC  

## NULL  

tryDistrib(b, "cauchy") #yes

## $fit
##      location      scale
##    15.7530893    3.6204942
##  ( 0.4959989) ( 0.3886226)
##  

## $loglik
## [1] -479.3897
##  

## $AIC
## NULL  

tryDistrib(b, "exp") #nope

## $fit
## [1] "fit failed"
##  

## $loglik
## [1] "no loglik computed"
##  

## $AIC
## [1] "no aic computed"
tryDistrib(b, "log") #nope

## $fit
## [1] "fit failed"
##  

## $loglik
## [1] "no loglik computed"
##  

## $AIC
## [1] "no aic computed"
tryDistrib(b, "t") #nope

## $fit
## [1] "fit failed"
##  

## $loglik
## [1] "no loglik computed"
##  

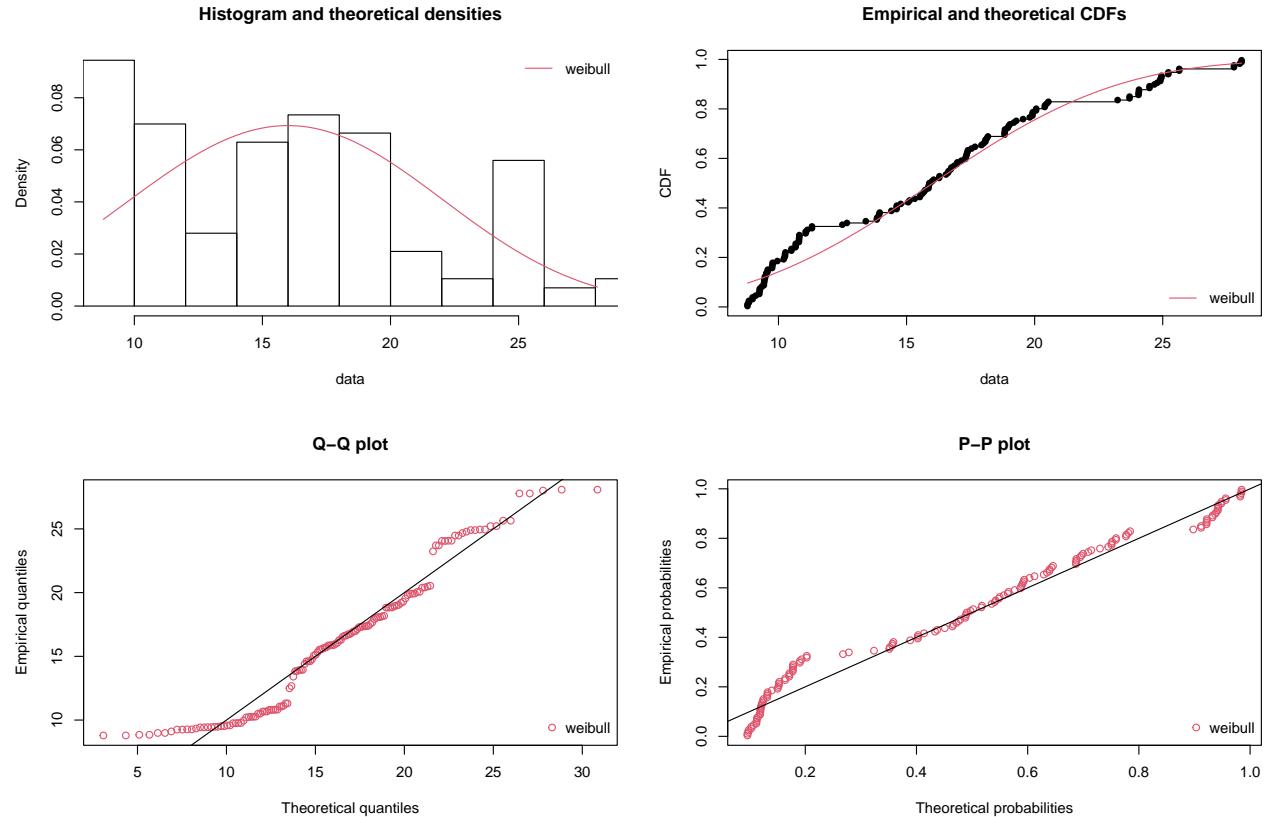
## $AIC
## [1] "no aic computed"
findGoodDist(b, "normal", "weibull")

## $normal
## $normal$fit
##      mean      sd
##    16.0612546    5.4521888
##  ( 0.4559349) ( 0.3223947)
##
```

```

## $normal$loglik
## [1] -445.4387
##
## $normal$AIC
## NULL

```

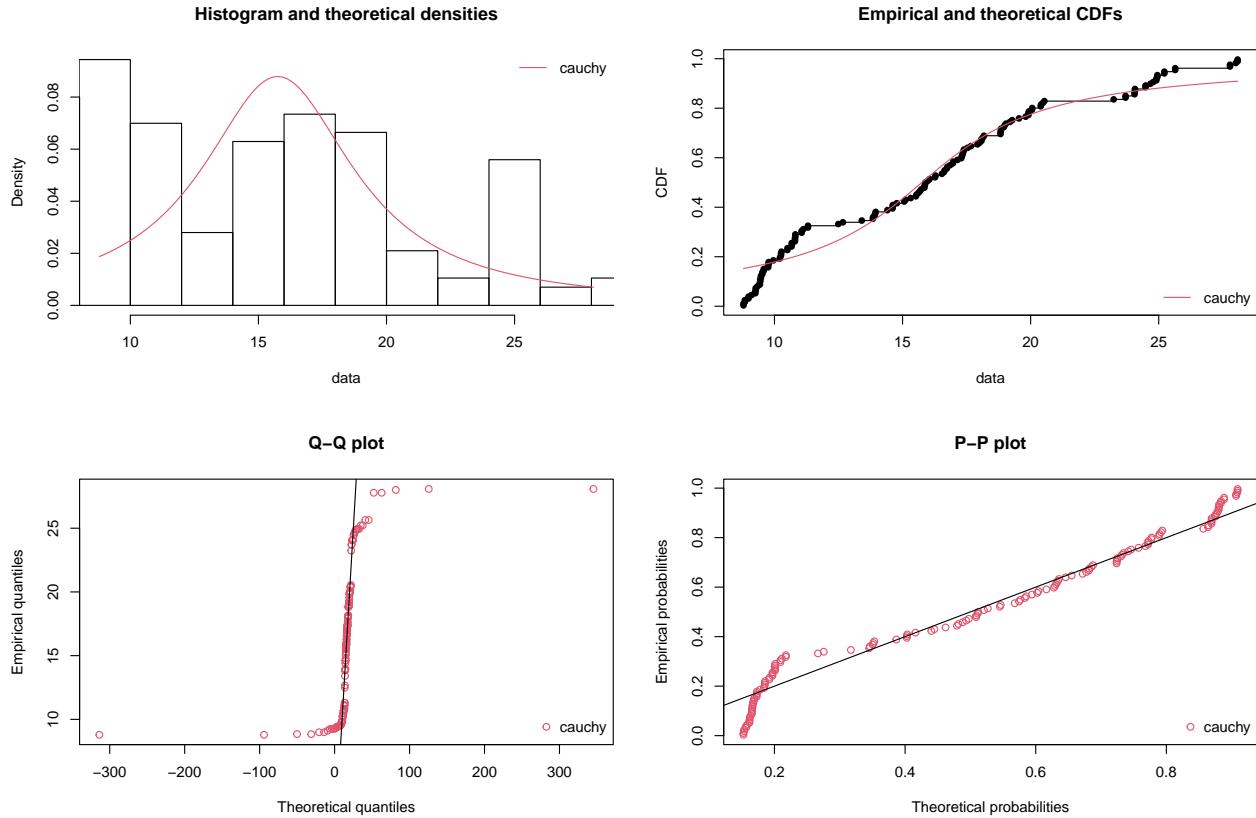


```
findGoodDist(b, "normal", "cauchy")
```

```

## $normal
## $normal$fit
##       mean           sd
##    16.0612546   5.4521888
##  ( 0.4559349) ( 0.3223947)
##
## $normal$loglik
## [1] -445.4387
##
## $normal$AIC
## NULL

```



Cauchy?

For some reason I am seeing Cauchy distributions everywhere. Please help me.

Standardization

I am now ignoring this part as the standardization didn't have much of an impact in my imputations.

Transforming the features to have the properties of a standard normal distribution with mean = 0 and standard deviation = 1

I have tried the imputations with the standardized and non-standardized data and I am getting the same results. Therefore I am ditching this "standardization".

```
# function to standardize data
#standardize <- function(x) {
#  return ((x - mean(x, na.rm = TRUE)) /
#          sd(x, na.rm = TRUE))
#}

#summary(x) # facs
#summary(y) # gene

#testing the function
#x_stand <- standardize(x)

#fitur::fit_dist_addin()

#summary(x_stand)
```

```

# create a data frame with only the variables to standardize
#genes_facs_df <- hm %>%
# dplyr::select(all_of(c(Facs_lab, Gene_lab, Facs_wild, Genes_wild)))

# apply the standardize function on all the numeric variables
#std_data <- as.data.frame(lapply(genes_facs_df, standardize))

#colnames(std_data) <- paste(colnames(std_data), "std", sep = "_")

# join the standardized data to our data set
#hm <- cbind(hm, std_data)

#remove the non-standardized data

#hm <- hm %>%
# dplyr::select(-all_of(c(Facs_lab, Gene_lab, Facs_wild, Genes_wild)))

```

Imputing missing data

Here is a beautiful graphic guide for my imputations. <https://stefvanbuuren.name/fimd/sec-toomany.html>
I will be using the package MICE (multivariate Imputation by chained Equations) which only requires a data frame of missing observations.

Description: *Multiple imputation using Fully Conditional Specification (FCS)*

implemented by the MICE algorithm as described in Van Buuren and Groothuis-Oudshoorn (2011) doi: 10.18637/jss.v045.i03. Each variable has its own imputation model. Built-in imputation models are provided for continuous data (predictive mean matching, normal), binary data (logistic regression), unordered categorical data (polytomous logistic regression) and ordered categorical data (proportional odds). MICE can also impute continuous two-level data (normal model, pan, second-level variables). Passive imputation can be used to maintain consistency between variables. Various diagnostic plots are available to inspect the quality of the imputations.

<https://www.jstatsoft.org/article/view/v045i03>

tutorial: <https://www.youtube.com/watch?v=WPiYOS3qK70>

<https://datascienceplus.com/imputing-missing-data-with-r-mice-package/>

<https://datascienceplus.com/handling-missing-data-with-mice-package-a-simple-approach/>

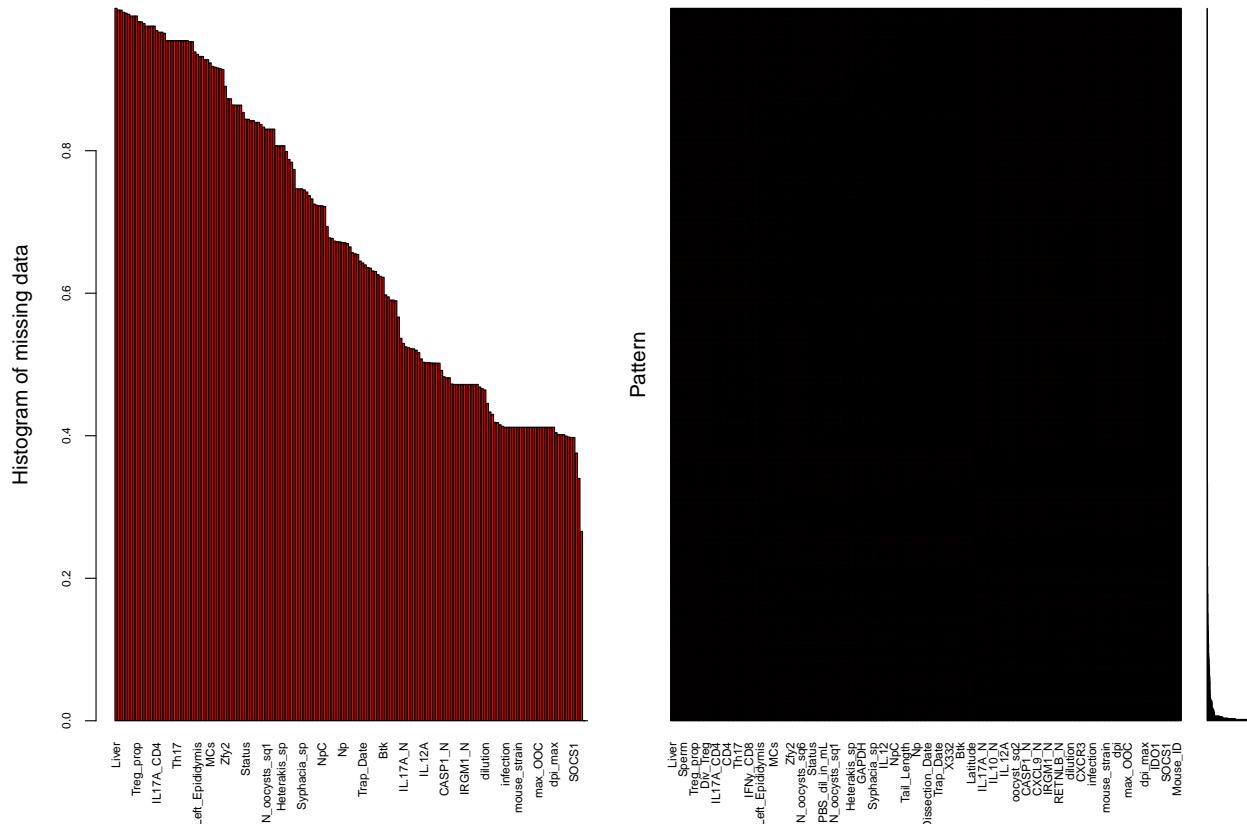
Missing data can be classified into three categories:

1. **Missing completely at random (MCAR)** We can't probably predict that value from any other value in the data. MCAR implies the reason for the missingness of a field is completely random, and that we probably can't predict that value from any other value in the data.
2. **Missing at Random (MAR)** Missingess can be explained by other values in other columns, but not from that column.
3. **Missing NOT at random (MNAR)** The basic MICE assumption is that the data is missing at random, and that we can make a guess about its true value by looking at other data samples.

Step1 : cleaning and checking the missing data points in our field data.

```
hm %>%
  aggr(col = c('navyblue', 'red'), numbers = TRUE, sortVars = TRUE,
    labels=names(hm), cex.axis=.7, gap=3,
    ylab=c("Histogram of missing data","Pattern"))

## Warning in plot.aggr(res, ...): not enough vertical space to display frequencies
## (too many combinations)
```



```
## 
## Variables sorted by number of missings:
##           Variable      Count
##             Liver 0.9997855458
##             Host 0.9974265494
##             Ticks 0.9972120952
##            IFNy_FEC 0.9942097362
##            Sperm 0.9929230109
##            batch 0.9914218314
##            OPG_O 0.9890628351
##            Caecum 0.9890628351
##            Treg_prop 0.9890628351
## Right_Ovary_Weight 0.9811280292
## Left_Ovary_Weight 0.9809135750
##            Y 0.9785545786
##            Div_Treg 0.9749088570
##            Div_Th1 0.9749088570
##            Div_Th17 0.9749088570
```

```

##          Div_Act_CD8 0.9749088570
##          IL17A_CD4 0.9686896848
##          Ct.Eimeria 0.9663306884
##          Ct.Mus 0.9663306884
##          eimeriaSpecies 0.9648295089
##          CD4 0.9545357066
##          Treg 0.9545357066
##          Treg17 0.9545357066
##          Th1 0.9545357066
##          Th17 0.9545357066
##          CD8 0.9545357066
##          Act_CD8 0.9545357066
##          IFNy_CD4 0.9545357066
##          IFNy_CD8 0.9545357066
##          Left_Embryo 0.9530345271
##          Right_Embryo 0.9530345271
##          IFNy_MES 0.9386660948
##          Left_Epididymis 0.9352348274
##          Left_Testis 0.9324469226
##          Right_Testis 0.9322324684
##          FEC_Eim_Ct 0.9277289299
##          MC.Eimeria.FEC 0.9277289299
##          MCs 0.9232253914
##  ILWE_DNA_Content_ng.microliter 0.9182929445
##          Ectoparasites_Logical 0.9172206734
##          Worms_presence 0.9161484023
##          Seminal_Vesicles_Weight 0.9150761312
##          Heligmosomoides_polygurus 0.9140038602
##          Zfy2 0.8904138966
##          Date_count 0.8732575595
##          counter 0.8728286511
##          N_oocysts_sq5 0.8642504825
##          N_oocysts_sq6 0.8640360283
##          N_oocysts_sq7 0.8640360283
##          N_oocysts_sq8 0.8640360283
##          IL.13_N 0.8537422260
##          Status 0.8443062406
##          mean_neubauer 0.8440917864
##          Oocyst_Predict_Crypto 0.8421616985
##          ILWE_Crypto_Ct 0.8421616985
##          PBS_dil_in_mL 0.8398027021
##          Ncells 0.8398027021
##          YNPAR 0.8368003431
##          OPG 0.8331546215
##          N_oocysts_sq1 0.8303667167
##          N_oocysts_sq2 0.8303667167
##          N_oocysts_sq3 0.8303667167
##          N_oocysts_sq4 0.8303667167
##          Catenotaenia_pusilla 0.8072056616
##          Mastophorus_muris 0.8069912074
##          Heterakis_sp 0.8069912074
##          Hymenolepis_sp 0.8069912074
##          Fleas 0.7988419472
##          IL.13 0.7876903281

```

```

##          GAPDH 0.7838301523
##          Es1C 0.7737508042
##          Trichuris_muris 0.7465151190
##          Aspicularis_sp 0.7465151190
##          Syphacia_sp 0.7465151190
##          Es1 0.7450139395
##          Region 0.7420115805
##          IRG6 0.7368646794
##          IL.12 0.7323611409
##          Sod1C 0.7250696976
##          Gpd1C 0.7235685181
##          Idh1C 0.7229251555
##          NpC 0.7227107013
##          MpiC 0.7216384302
##          Spleen 0.6935449282
##          Address 0.6776753163
##          Tail_Length 0.6770319537
##          Sod1 0.6731717778
##          Idh1 0.6723139610
##          Gpd1 0.6720995068
##          Np 0.6712416899
##          Body_Length 0.6708127815
##          Mpi 0.6697405104
##          Body_Weight 0.6650225177
##          Dissection_Date 0.6568732576
##          HI_NLoci 0.6553720781
##          IFNy_CEWE 0.6545142612
##          X65 0.6450782758
##          Trap_Date 0.6425048252
##          Taenia_sp 0.6397169204
##          Tsx 0.6360711988
##          HI 0.6352133819
##          X332 0.6313532061
##          Syap1 0.6304953892
##          X347 0.6262063050
##          mtBamH 0.6236328544
##          Btk 0.6223461291
##          Sex 0.5976838945
##          Year 0.5948959897
##          Longitude 0.5903924512
##          Latitude 0.5903924512
##          IFNy_N 0.5893201801
##          PRF1_N 0.5665880335
##          MPO_N 0.5367788977
##          IL.17A_N 0.5294874544
##          IL.17A 0.5247694617
##          PRF1 0.5234827364
##          NCR1_N 0.5224104654
##          IL.10_N 0.5219815569
##          IFNy 0.5200514690
##          IL.6_N 0.5168346558
##          IL.12A_N 0.5078275788
##          IL.12A 0.5031095861
##          004sq 0.5026806777

```

```

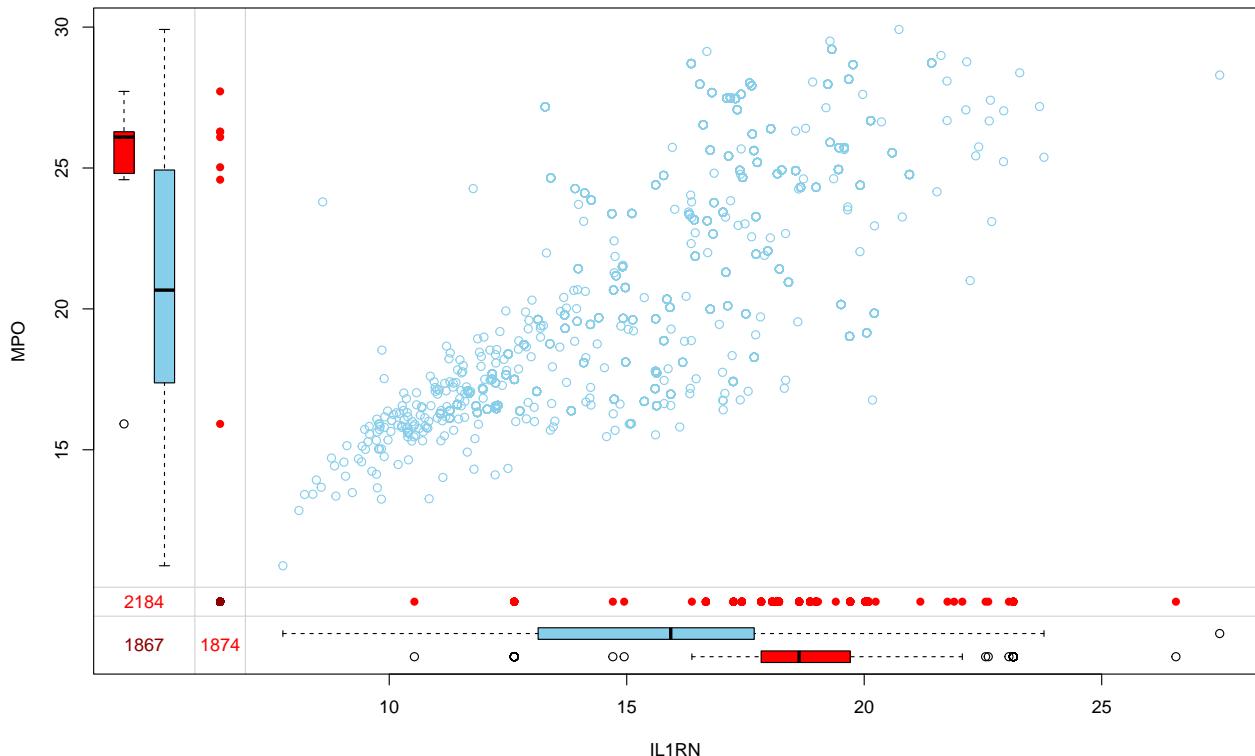
##          OOC 0.5026806777
##          oocyst_sq4 0.5022517692
##          oocyst_sq2 0.5020373150
##          oocyst_sq3 0.5020373150
##          oocyst_sq1 0.5018228608
##          IL.10 0.4917435128
##          CASP1_N 0.4827364358
##          TICAM1_N 0.4814497105
##          TNF_N 0.4814497105
##          NCR1 0.4726570877
##          CXCL9_N 0.4720137251
##          CXCR3_N 0.4720137251
##          IDO1_N 0.4720137251
##          IL1RN_N 0.4720137251
##          IRGM1_N 0.4720137251
##          MUC2_N 0.4720137251
##          MUC5AC_N 0.4720137251
##          MYD88_N 0.4720137251
##          RETNLB_N 0.4720137251
##          SOCS1_N 0.4720137251
##          MPO 0.4683680034
##          IL.6 0.4660090071
##          dilution 0.4642933734
##          PPIB 0.4454214025
##          CASP1 0.4334119665
##          TICAM1 0.4299806991
##          CXCR3 0.4188290800
##          RETNLB 0.4184001716
##          labels 0.4153978126
##          TNF 0.4132532704
##          infection 0.4119665451
##          end_rel_weight 0.4119665451
##          experiment 0.4119665451
##          primary_infection 0.4119665451
##          challenge_infection 0.4119665451
##          mouse_strain 0.4119665451
##          weight 0.4119665451
##          weight_dpi0 0.4119665451
##          relative_weight 0.4119665451
##          dpi 0.4119665451
##          infection_history 0.4119665451
##          Position 0.4119665451
##          max_dpi 0.4119665451
##          max_OOC 0.4119665451
##          max_WL 0.4119665451
##          death 0.4119665451
##          hybrid_status 0.4119665451
##          Parasite_primary 0.4119665451
##          Parasite_challenge 0.4119665451
##          dpi_max 0.4119665451
##          CXCL9 0.4042461934
##          IL1RN 0.4018871971
##          MUC5AC 0.4016727429
##          IDO1 0.4014582887

```

```

## MYD88 0.3995282007
## MUC2 0.3982414754
## IRGM1 0.3975981128
## SOCS1 0.3975981128
## delta_ct_cewe_MminusE 0.3757237830
## MC.Eimeria 0.3401243834
## Feces_Weight 0.2657087712
## Mouse_ID 0.0002144542
## origin 0.0000000000
marginplot(hm[c(35,38)])

```



Now let's continue by using the package MICE to impute the data

Lab

I first used standardized data. Now, I added # to remove these steps.

Now using raw data!

Stef Van Buuren advises of using up to 15 - 20 predictor variables. I have tried using the whole data set, which created chaos.

I am now using everything possible to use, even the variables that I will use in my further analysis.

- Further reading required here.

I divided the data into lab and field again, as it is only adding to the con

```

# lab samples
lab <- hm %>%
  filter(origin == "Lab", infection == "challenge", dpi == dpi_max)

```

```

gf_lab <- lab %>%
  dplyr::select(all_of(c(Facs_lab, Facs_wild, Gene_lab, Genes_wild)))

#remove rows with only nas
gf_lab <- gf_lab[, colSums(is.na(gf_lab)) < nrow(gf_lab)]

#remove columns with only nas
gf_lab <- gf_lab[rowSums(is.na(gf_lab)) != ncol(gf_lab), ]

#select same rows in the first table
lab <- lab[row.names(gf_lab), ]

#remove wrongly normalized genes
lab <- lab %>%
  dplyr::select(-ends_with("_N"))

lab[rowSums(is.na(lab)) != ncol(lab), ]

```

	infection	Mouse_ID	end_rel_weight	experiment	primary_infection
## 1	challenge	LM0227	99.79044	E57	E88
## 2	challenge	LM0228	110.69242	E57	E88
## 3	challenge	LM0229	99.73767	E57	E88
## 4	challenge	LM0231	98.74335	E57	E88
## 5	challenge	LM0232	102.31323	E57	E88
## 6	challenge	LM0233	100.63823	E57	E88
## 7	challenge	LM0234	99.63370	E57	E88
## 8	challenge	LM0235	99.64249	E57	E88
## 9	challenge	LM0236	103.04762	E57	E88
## 10	challenge	LM0238	95.41842	E57	E88
## 11	challenge	LM0239	95.15714	E57	E88
## 12	challenge	LM0240	100.00000	E57	E88
## 13	challenge	LM0247	95.57685	E57	E88
## 14	challenge	LM0248	87.72379	E57	E88
## 15	challenge	LM0249	93.48659	E57	E88
## 16	challenge	LM0251	94.30052	E57	E88
## 17	challenge	LM0254	94.26523	E57	E88
## 18	challenge	LM0255	93.04491	E57	E88
## 19	challenge	LM0256	102.29846	E57	E88
## 20	challenge	LM0257	89.84615	E57	E88
## 21	challenge	LM0258	92.60385	E57	E64
## 22	challenge	LM0259	98.02700	E57	E64
## 23	challenge	LM0260	93.24604	E57	E64
## 24	challenge	LM0261	93.03136	E57	E64
## 25	challenge	LM0262	108.61335	E57	E64
## 26	challenge	LM0263	100.04706	E57	E64
## 27	challenge	LM0264	99.60850	E57	E64
## 28	challenge	LM0265	99.77299	E57	E64
## 29	challenge	LM0266	81.82957	E57	E64
## 30	challenge	LM0268	91.69866	E57	E64
## 31	challenge	LM0269	98.10185	E57	E64
## 32	challenge	LM0270	96.31645	E57	E64
## 33	challenge	LM0271	96.24742	E57	E64
## 34	challenge	LM0272	100.04392	E57	E64

## 35	challenge	LM0273	100.50691	E57	E64
## 36	challenge	LM0275	107.87326	E57	E64
## 37	challenge	LM0276	104.90030	E57	E64
## 38	challenge	LM0277	98.91122	E57	E64
## 39	challenge	LM0278	106.51341	E57	E64
## 40	challenge	LM0279	99.62529	E57	E64
## 41	challenge	LM0280	105.29311	E57	E64
## 42	challenge	LM0282	116.45065	E57	E64
## 43	challenge	LM0283	101.30890	E57	E64
## 44	challenge	LM0284	105.18088	E57	E64
## 45	challenge	LM0285	101.18374	E57	E64
## 46	challenge	LM0286	107.02674	E57	E64
## 47	challenge	LM0287	110.72756	E57	E64
## 48	challenge	LM0288	101.16515	E57	E64
## 49	challenge	LM0289	91.64229	E57	E64
## 51	challenge	LM0292	101.39955	E57	E64
## 52	challenge	LM0293	95.75699	E57	E64
## 53	challenge	LM0294	97.94360	E57	E64
## 54	challenge	LM0332	98.63548	P3	Eflab
## 55	challenge	LM0333	91.40000	P3	Eflab
## 56	challenge	LM0334	95.34884	P3	Eflab
## 57	challenge	LM0335	97.02128	P3	E88
## 58	challenge	LM0336	86.80688	P3	E88
## 62	challenge	LM0340	92.72388	P3	E64
## 64	challenge	LM0342	85.25180	P3	E139
## 65	challenge	LM0343	93.62832	P3	E139
## 66	challenge	LM0344	96.09053	P3	UNI
## 67	challenge	LM0345	89.18919	P3	UNI
## 68	challenge	LM0346	92.85714	P3	UNI
## 69	challenge	LM0347	87.40955	P3	E88
## 70	challenge	LM0352	92.42640	P4	E64
## 71	challenge	LM0352	92.42640	P4	E64
## 72	challenge	LM0353	92.33926	P4	E64
## 73	challenge	LM0353	92.33926	P4	E64
## 74	challenge	LM0354	97.21489	P4	E64
## 75	challenge	LM0354	97.21489	P4	E64
## 76	challenge	LM0355	105.49618	P4	E64
## 77	challenge	LM0355	105.49618	P4	E64
## 78	challenge	LM0356	96.51978	P4	E88
## 79	challenge	LM0356	96.51978	P4	E88
## 80	challenge	LM0357	89.03181	P4	E88
## 81	challenge	LM0357	89.03181	P4	E88
## 82	challenge	LM0358	92.77494	P4	E88
## 83	challenge	LM0358	92.77494	P4	E88
## 84	challenge	LM0359	97.79202	P4	E88
## 85	challenge	LM0359	97.79202	P4	E88
## 86	challenge	LM0361	87.00997	P4	Eflab
## 87	challenge	LM0361	87.00997	P4	Eflab
## 88	challenge	LM0363	96.38135	P4	Eflab
## 89	challenge	LM0363	96.38135	P4	Eflab
## 90	challenge	LM0364	81.90944	P4	UNI
## 91	challenge	LM0364	81.90944	P4	UNI
## 92	challenge	LM0365	77.93483	P4	UNI
## 93	challenge	LM0365	77.93483	P4	UNI

## 94 challenge	LM0366	84.21604	P4	UNI
## 95 challenge	LM0367	93.92379	P4	UNI
## 96 challenge	LM0367	93.92379	P4	UNI
## 97 challenge	LM0368	95.71776	E10	E64
## 98 challenge	LM0369	91.33938	E10	E64
## 99 challenge	LM0370	99.12136	E10	E64
## 100 challenge	LM0372	86.13021	E10	E64
## 101 challenge	LM0373	79.90448	E10	E64
## 102 challenge	LM0375	80.27901	E10	E64
## 103 challenge	LM0376	104.07623	E10	E64
## 104 challenge	LM0377	96.00216	E10	E64
## 105 challenge	LM0379	103.73719	E10	E64
## 106 challenge	LM0380	91.56379	E10	E88
## 107 challenge	LM0385	94.35532	E10	E88
## 108 challenge	LM0389	103.86039	E10	E88
## 110 challenge	LM0393	99.33943	E10	UNI
## 111 challenge	LM0394	104.82721	E10	UNI
## 112 challenge	LM0395	104.90834	E10	UNI
## 113 challenge	LM0396	101.32721	E10	UNI
## 114 challenge	LM0397	101.43849	E10	UNI
## 115 challenge	LM0398	100.32573	E10	UNI
## 116 challenge	LM0399	81.21109	E10	UNI
## 117 challenge	LM0400	101.71745	E11	E64
## 118 challenge	LM0400	101.71745	E11	E64
## 119 challenge	LM0401	97.85867	E11	UNI
## 120 challenge	LM0401	97.85867	E11	UNI
## 121 challenge	LM0402	85.76372	E11	UNI
## 122 challenge	LM0402	85.76372	E11	UNI
## 123 challenge	LM0404	98.12672	E11	E64
## 124 challenge	LM0404	98.12672	E11	E64
## 125 challenge	LM0406	77.00535	E11	UNI
## 126 challenge	LM0407	99.36128	E11	UNI
## 127 challenge	LM0407	99.36128	E11	UNI
## 128 challenge	LM0408	77.80488	E11	E64
## 129 challenge	LM0408	77.80488	E11	E64
## 130 challenge	LM0410	105.40858	E11	E64
## 131 challenge	LM0410	105.40858	E11	E64
## 132 challenge	LM0411	83.27273	E11	E64
## 133 challenge	LM0411	83.27273	E11	E64
## 134 challenge	LM0412	78.11052	E11	UNI
## 135 challenge	LM0412	78.11052	E11	UNI
## 136 challenge	LM0413	95.77811	E11	E64
## 137 challenge	LM0413	95.77811	E11	E64
## 138 challenge	LM0415	90.44118	E11	UNI
## 139 challenge	LM0415	90.44118	E11	UNI
## 140 challenge	LM0417	75.33199	E11	E64
## 141 challenge	LM0417	75.33199	E11	E64
## 142 challenge	LM0420	90.31579	E11	E88
## 143 challenge	LM0420	90.31579	E11	E88
## 144 challenge	LM0421	80.74667	E11	UNI
## 145 challenge	LM0422	73.44595	E11	E64
## 146 challenge	LM0422	73.44595	E11	E64
## 147 challenge	LM0424	97.19134	E11	E64
## 148 challenge	LM0424	97.19134	E11	E64

## 149 challenge	LM0425	99.71783	E11	UNI	
## 150 challenge	LM0425	99.71783	E11	UNI	
## 151 challenge	LM0426	102.66112	E11	E88	
## 152 challenge	LM0426	102.66112	E11	E88	
## 153 challenge	LM0428	94.96729	E11	E88	
## 154 challenge	LM0428	94.96729	E11	E88	
## 155 challenge	LM0429	80.47099	E11	E88	
## 156 challenge	LM0430	95.84545	E11	UNI	
## 157 challenge	LM0430	95.84545	E11	UNI	
## 158 challenge	LM0431	95.85492	E11	E64	
## 159 challenge	LM0431	95.85492	E11	E64	
## challenge_infection	mouse_strain	labels	weight	weight_dpi0	
## 1	E64	BUSNA_STR	E57bxMNW	23.81	23.86
## 2	E64	STR	E57bxBGY	23.50	21.23
## 3	UNI	SCHUNT_SCHUNT	E57bxEMW	19.01	19.06
## 4	E64	PWD_SCHUNT	E57bxCEK	20.43	20.69
## 5	UNI	BUSNA_STR	E57bxCUY	26.98	26.37
## 6	UNI	STR	E57bxSTU	29.96	29.77
## 7	E64	STR	E57bxBLW	32.64	32.76
## 8	E64	STR	E57bxDTU	19.51	19.58
## 9	E64	STR	E57bxFRU	27.05	26.25
## 10	E64	PWD	E57bxLYZ	20.41	21.39
## 11	UNI	SCHUNT_SCHUNT	E57bxJMR	18.47	19.41
## 12	E64	SCHUNT_PWD	E57bxCIW	20.45	20.45
## 13	UNI	STR	E57bxJMX	25.93	27.13
## 14	E64	STR	E57bxAPS	20.58	23.46
## 15	E64	SCHUNT_STR	E57bxPSV	24.40	26.10
## 16	UNI	STR	E57bxEOT	21.84	23.16
## 17	UNI	SCHUNT_PWD	E57bxBCD	21.04	22.32
## 18	E64	BUSNA	E57bxMOR	16.99	18.26
## 19	UNI	STR	E57bxJVZ	29.82	29.15
## 20	E64	SCHUNT_SCHUNT	E57bxJQU	20.44	22.75
## 21	E64	BUSNA	E57bxHVV	18.28	19.74
## 22	E64	STR	E57bxGHI	28.32	28.89
## 23	E64	SCHUNT_SCHUNT	E57byGHV	27.06	29.02
## 24	UNI	PWD	E57bxKOP	18.69	20.09
## 25	E64	BUSNA	E57byABO	22.95	21.13
## 26	E64	PWD	E57byLMZ	21.26	21.25
## 27	UNI	PWD	E57bxADL	17.81	17.88
## 28	E64	BUSNA	E57byIMQ	26.37	26.43
## 29	UNI	SCHUNT	E57bxIOS	19.59	23.94
## 30	UNI	SCHUNT_SCHUNT	E57bxGSW	19.11	20.84
## 31	E64	STR	E57byLOT	21.19	21.60
## 32	E64	SCHUNT	E57byKMQ	23.01	23.89
## 33	UNI	STR	E57bxPSU	23.34	24.25
## 34	UNI	BUSNA	E57byAYZ	22.78	22.77
## 35	UNI	STR	E57byKQW	21.81	21.70
## 36	UNI	SCHUNT	E57byMNW	22.47	20.83
## 37	UNI	STR	E57byBGY	31.04	29.59
## 38	UNI	BUSNA	E57byCEK	23.62	23.88
## 39	UNI	SCHUNT	E57byDTU	22.24	20.88
## 40	E64	BUSNA	E57byFPV	21.27	21.35
## 41	E64	SCHUNT_SCHUNT	E57byMRZ	18.50	17.57
## 42	UNI	STR	E57byFRU	35.04	30.09

## 43	UNI	PWD_PWD	E57byLYZ	19.35	19.10
## 44	E64	STRA_BUSNA	E57byLRS	23.55	22.39
## 45	E64	PWD_PWD	E57byBMX	19.66	19.43
## 46	UNI	PWD_BUSNA	E57byCWZ	20.41	19.07
## 47	E64	BUSNA_PWD	E57byPRZ	20.85	18.83
## 48	UNI	PWD_BUSNA	E57byCIW	19.97	19.74
## 49	UNI	SCHUNT_SCHUNT	E57byPSV	21.93	23.93
## 51	UNI	BUSNA_PWD	E57byMOR	22.46	22.15
## 52	UNI	BUSNA_BUSNA	E57byJQU	19.86	20.74
## 53	E64	PWD_PWD	E57byFLN	16.67	17.02
## 54	E88	NMRI	P3bTBI	50.60	51.30
## 55	E64	NMRI	P3bBTL	45.70	50.00
## 56	UNI	NMRI	P3bRLW	45.10	47.30
## 57	UNI	NMRI	P3bIIT	45.60	47.00
## 58	E64	NMRI	P3bXFQ	45.40	52.30
## 62	UNI	NMRI	P3bFLD	49.70	53.60
## 64	E64	NMRI	P3bEVY	47.40	55.60
## 65	UNI	NMRI	P3bBQA	52.90	56.50
## 66	E88	NMRI	<NA>	46.70	48.60
## 67	E64	NMRI	P3bIHD	52.80	59.20
## 68	UNI	NMRI	P3bVJA	49.40	53.20
## 69	E88	NMRI	P3bFMI	60.40	69.10
## 70	E88	NMRI	P4bRXD	38.93	42.12
## 71	E88	NMRI	P4bRXD	38.93	42.12
## 72	E88	NMRI	P4bIFU	40.50	43.86
## 73	E88	NMRI	P4bIFU	40.50	43.86
## 74	E64	NMRI	P4bMOP	40.49	41.65
## 75	E64	NMRI	P4bMOP	40.49	41.65
## 76	UNI	NMRI	P4bKJY	48.37	45.85
## 77	UNI	NMRI	P4bKJY	48.37	45.85
## 78	E88	NMRI	P4bQSH	38.55	39.94
## 79	E88	NMRI	P4bQSH	38.55	39.94
## 80	E88	NMRI	P4bXUM	38.07	42.76
## 81	E88	NMRI	P4bXUM	38.07	42.76
## 82	E64	NMRI	P4bGAB	43.53	46.92
## 83	E64	NMRI	P4bGAB	43.53	46.92
## 84	UNI	NMRI	P4bYNV	41.19	42.12
## 85	UNI	NMRI	P4bYNV	41.19	42.12
## 86	E88	NMRI	P4bRLM	37.51	43.11
## 87	E88	NMRI	P4bRLM	37.51	43.11
## 88	UNI	NMRI	P4bPQS	41.55	43.11
## 89	UNI	NMRI	P4bPQS	41.55	43.11
## 90	E88	NMRI	P4bSMQ	38.35	46.82
## 91	E88	NMRI	P4bSMQ	38.35	46.82
## 92	E88	NMRI	P4bGXY	52.38	67.21
## 93	E88	NMRI	P4bGXY	52.38	67.21
## 94	E64	NMRI	P4bPBN	40.23	47.77
## 95	UNI	NMRI	P4bXOQ	45.60	48.55
## 96	UNI	NMRI	P4bXOQ	45.60	48.55
## 97	E64	SCHUNT_SCHUNT	E10bBWZ	19.67	20.55
## 98	E64	SCHUNT_SCHUNT	E10bQBG	18.14	19.86
## 99	E64	PWD_PWD	E10bVIV	18.05	18.21
## 100	E88	SCHUNT_SCHUNT	E10bAHH	21.30	24.73
## 101	E88	SCHUNT_SCHUNT	E10bEJZ	21.75	27.22

## 102	E88	PWD_PWD	E10bLFS	12.66	15.77
## 103	UNI	SCHUNT_SCHUNT	E10bMVN	19.66	18.89
## 104	UNI	SCHUNT_SCHUNT	E10bLQS	17.77	18.51
## 105	UNI	PWD_PWD	E10bTSD	17.21	16.59
## 106	E88	SCHUNT_SCHUNT	E10bVKF	17.80	19.44
## 107	E64	SCHUNT_SCHUNT	E10bPNK	15.88	16.83
## 108	UNI	SCHUNT_SCHUNT	E10bVXW	19.64	18.91
## 110	UNI	SCHUNT_SCHUNT	E10bOET	19.55	19.68
## 111	UNI	PWD_PWD	E10bXCZ	19.11	18.23
## 112	UNI	PWD_PWD	E10bPON	17.74	16.91
## 113	E64	SCHUNT_SCHUNT	E10bLCS	19.85	19.59
## 114	E64	PWD_PWD	E10bIFF	20.45	20.16
## 115	E88	SCHUNT_SCHUNT	E10bQSC.1	18.48	18.42
## 116	E88	PWD_PWD	E10bPSW	14.35	17.67
## 117	E64	SCHUNT_SCHUNT	E11bIJQ	18.36	18.05
## 118	E64	SCHUNT_SCHUNT	E11bIJQ	18.36	18.05
## 119	UNI	SCHUNT_SCHUNT	E11bAHY	18.28	18.68
## 120	UNI	SCHUNT_SCHUNT	E11bAHY	18.28	18.68
## 121	E64	SCHUNT_SCHUNT	E11bDLP	17.35	20.23
## 122	E64	SCHUNT_SCHUNT	E11bDLP	17.35	20.23
## 123	E64	PWD_PWD	E11bBSZ	17.81	18.15
## 124	E64	PWD_PWD	E11bBSZ	17.81	18.15
## 125	E88	SCHUNT_SCHUNT	E11bDMR	14.40	18.70
## 126	E64	SCHUNT_SCHUNT	E11bAOS	24.89	25.05
## 127	E64	SCHUNT_SCHUNT	E11bAOS	24.89	25.05
## 128	E88	PWD_PWD	E11bINQ	12.76	16.40
## 129	E88	PWD_PWD	E11bINQ	12.76	16.40
## 130	E64	PWD_PWD	E11bOTY	17.93	17.01
## 131	E64	PWD_PWD	E11bOTY	17.93	17.01
## 132	E88	PWD_PWD	E11bBNU	13.74	16.50
## 133	E88	PWD_PWD	E11bBNU	13.74	16.50
## 134	E64	SCHUNT_SCHUNT	E11bEFU	21.91	28.05
## 135	E64	SCHUNT_SCHUNT	E11bEFU	21.91	28.05
## 136	UNI	SCHUNT_SCHUNT	E11bPWY	19.51	20.37
## 137	UNI	SCHUNT_SCHUNT	E11bPWY	19.51	20.37
## 138	E64	SCHUNT_SCHUNT	E11bDGH	20.91	23.12
## 139	E64	SCHUNT_SCHUNT	E11bDGH	20.91	23.12
## 140	E88	SCHUNT_SCHUNT	E11bAEM	18.72	24.85
## 141	E88	SCHUNT_SCHUNT	E11bAEM	18.72	24.85
## 142	E88	SCHUNT_SCHUNT	E11bABD	17.16	19.00
## 143	E88	SCHUNT_SCHUNT	E11bABD	17.16	19.00
## 144	E64	PWD_PWD	E11bGOP	15.14	18.75
## 145	E88	PWD_PWD	E11bELU	10.87	14.80
## 146	E88	PWD_PWD	E11bELU	10.87	14.80
## 147	UNI	PWD_PWD	E11bGQZ	16.61	17.09
## 148	UNI	PWD_PWD	E11bGQZ	16.61	17.09
## 149	UNI	PWD_PWD	E11bBFZ	17.67	17.72
## 150	UNI	PWD_PWD	E11bBFZ	17.67	17.72
## 151	UNI	SCHUNT_SCHUNT	E11bAYZ	24.69	24.05
## 152	UNI	SCHUNT_SCHUNT	E11bAYZ	24.69	24.05
## 153	E64	SCHUNT_SCHUNT	E11bJOR	18.87	19.87
## 154	E64	SCHUNT_SCHUNT	E11bJOR	18.87	19.87
## 155	E64	PWD_PWD	E11bHJY	14.01	17.41
## 156	UNI	SCHUNT_SCHUNT	E11bJLX	23.07	24.07

	UNI	SCHUNT_SCHUNT	E11bJLX	23.07	24.07
## 158	E64	SCHUNT_SCHUNT	E11bOSZ	18.50	19.30
## 159	E64	SCHUNT_SCHUNT	E11bOSZ	18.50	19.30
## relative_weight	Feces_Weight	dpi	oocyst_sq1	oocyst_sq2	oocyst_sq3
## 1	99.79044	2.73	8	3	5
## 2	110.69242	1.13	8	13	6
## 3	99.73767	2.36	8	0	0
## 4	98.74335	2.81	8	13	15
## 5	102.31323	2.15	8	0	0
## 6	100.63823	1.75	8	0	0
## 7	99.63370	1.63	8	4	10
## 8	99.64249	0.95	8	1	0
## 9	103.04762	2.33	8	8	4
## 10	95.41842	1.38	8	22	23
## 11	95.15714	2.87	8	0	0
## 12	100.00000	1.39	8	0	0
## 13	95.57685	7.14	8	0	1
## 14	87.72379	2.50	8	0	2
## 15	93.48659	2.71	8	1	0
## 16	94.30052	1.32	8	0	0
## 17	94.26523	3.97	8	0	0
## 18	93.04491	1.41	8	5	11
## 19	102.29846	2.16	8	0	0
## 20	89.84615	1.46	8	4	1
## 21	92.60385	1.22	8	4	4
## 22	98.02700	2.58	8	2	0
## 23	93.24604	3.14	8	0	0
## 24	93.03136	1.36	8	0	0
## 25	108.61335	1.42	8	1	0
## 26	100.04706	1.56	8	4	8
## 27	99.60850	1.01	8	0	0
## 28	99.77299	2.45	8	0	0
## 29	81.82957	2.79	8	0	0
## 30	91.69866	2.11	8	0	0
## 31	98.10185	1.22	8	0	0
## 32	96.31645	1.58	8	0	0
## 33	96.24742	2.08	8	0	0
## 34	100.04392	1.48	8	0	0
## 35	100.50691	2.00	8	0	0
## 36	107.87326	1.19	8	0	0
## 37	104.90030	1.00	8	0	0
## 38	98.91122	1.52	8	0	0
## 39	106.51341	1.17	8	0	0
## 40	99.62529	1.10	8	0	2
## 41	105.29311	1.42	8	0	0
## 42	116.45065	1.96	8	0	0
## 43	101.30890	1.49	8	0	0
## 44	105.18088	1.50	8	0	0
## 45	101.18374	1.40	8	14	13
## 46	107.02674	1.44	8	0	0
## 47	110.72756	1.27	8	0	0
## 48	101.16515	1.37	8	0	0
## 49	91.64229	2.23	8	0	0
## 51	101.39955	1.29	8	0	0

## 52	95.75699	1.24	8	0	0	0
## 53	97.94360	1.00	8	1	4	4
## 54	98.63548	2.40	8	0	0	0
## 55	91.40000	NA	8	NA	NA	NA
## 56	95.34884	2.15	8	0	0	0
## 57	97.02128	1.78	8	0	0	0
## 58	86.80688	NA	8	NA	NA	NA
## 62	92.72388	2.44	8	0	0	0
## 64	85.25180	NA	8	NA	NA	NA
## 65	93.62832	1.62	8	0	0	0
## 66	96.09053	NA	2	NA	NA	NA
## 67	89.18919	NA	8	NA	NA	NA
## 68	92.85714	1.87	8	0	0	0
## 69	87.40955	2.65	8	0	2	0
## 70	92.42640	2.53	8	50	45	39
## 71	92.42640	2.53	8	50	45	39
## 72	92.33926	1.93	8	67	75	64
## 73	92.33926	1.93	8	67	75	64
## 74	97.21489	3.03	8	0	0	0
## 75	97.21489	3.03	8	0	0	0
## 76	105.49618	2.87	8	0	0	0
## 77	105.49618	2.87	8	0	0	0
## 78	96.51978	3.24	8	0	0	0
## 79	96.51978	3.24	8	0	0	0
## 80	89.03181	1.46	8	0	0	0
## 81	89.03181	1.46	8	0	0	0
## 82	92.77494	4.61	8	3	2	1
## 83	92.77494	4.61	8	3	2	1
## 84	97.79202	2.21	8	0	0	0
## 85	97.79202	2.21	8	0	0	0
## 86	87.00997	2.60	8	1	1	1
## 87	87.00997	2.60	8	1	1	1
## 88	96.38135	2.05	8	0	0	0
## 89	96.38135	2.05	8	0	0	0
## 90	81.90944	0.77	8	20	23	20
## 91	81.90944	0.77	8	20	23	20
## 92	77.93483	0.24	8	0	0	0
## 93	77.93483	0.24	8	0	0	0
## 94	84.21604	0.47	5	46	30	39
## 95	93.92379	2.31	8	0	0	0
## 96	93.92379	2.31	8	0	0	0
## 97	95.71776	1.37	8	0	0	0
## 98	91.33938	1.13	8	0	0	0
## 99	99.12136	1.18	8	2	1	1
## 100	86.13021	0.80	8	35	55	50
## 101	79.90448	0.13	8	2	3	5
## 102	80.27901	0.26	8	14	23	15
## 103	104.07623	1.11	8	0	0	0
## 104	96.00216	1.63	8	0	0	0
## 105	103.73719	0.68	8	0	0	0
## 106	91.56379	1.01	8	0	2	1
## 107	94.35532	1.64	8	0	0	0
## 108	103.86039	1.07	8	0	0	0
## 110	99.33943	1.16	8	0	0	0

	##	111	104.82721	1.08	8	0	0	0
	##	112	104.90834	0.91	8	0	0	0
	##	113	101.32721	1.05	8	2	1	0
	##	114	101.43849	1.11	8	29	15	20
	##	115	100.32573	0.90	8	102	100	91
	##	116	81.21109	0.26	8	37	31	36
	##	117	101.71745	NA	8	0	0	0
	##	118	101.71745	NA	8	0	0	0
	##	119	97.85867	NA	8	0	0	0
	##	120	97.85867	NA	8	0	0	0
	##	121	85.76372	NA	8	4	1	0
	##	122	85.76372	NA	8	4	1	0
	##	123	98.12672	NA	8	0	0	0
	##	124	98.12672	NA	8	0	0	0
	##	125	77.00535	0.61	7	3	1	0
	##	126	99.36128	NA	8	0	0	0
	##	127	99.36128	NA	8	0	0	0
	##	128	77.80488	NA	8	6	3	6
	##	129	77.80488	NA	8	6	3	6
	##	130	105.40858	NA	8	2	0	1
	##	131	105.40858	NA	8	2	0	1
	##	132	83.27273	NA	8	17	15	19
	##	133	83.27273	NA	8	17	15	19
	##	134	78.11052	NA	8	0	1	1
	##	135	78.11052	NA	8	0	1	1
	##	136	95.77811	NA	8	0	0	0
	##	137	95.77811	NA	8	0	0	0
	##	138	90.44118	NA	8	0	0	1
	##	139	90.44118	NA	8	0	0	1
	##	140	75.33199	NA	8	1	2	1
	##	141	75.33199	NA	8	1	2	1
	##	142	90.31579	NA	8	0	0	0
	##	143	90.31579	NA	8	0	0	0
	##	144	80.74667	NA	6	NA	NA	NA
	##	145	73.44595	NA	8	3	5	3
	##	146	73.44595	NA	8	3	5	3
	##	147	97.19134	NA	8	0	0	0
	##	148	97.19134	NA	8	0	0	0
	##	149	99.71783	NA	8	0	0	0
	##	150	99.71783	NA	8	0	0	0
	##	151	102.66112	NA	8	0	0	0
	##	152	102.66112	NA	8	0	0	0
	##	153	94.96729	NA	8	0	0	0
	##	154	94.96729	NA	8	0	0	0
	##	155	80.47099	NA	6	NA	NA	NA
	##	156	95.84545	NA	8	0	0	0
	##	157	95.84545	NA	8	0	0	0
	##	158	95.85492	NA	8	0	0	0
	##	159	95.85492	NA	8	0	0	0
	##		oocyst_sq4	dilution	004sq	00C	infection_history	MC.Eimeria
	##	1	1	1	17	42500	falciformis_ferrisi	TRUE
	##	2	6	1	36	90000	falciformis_ferrisi	TRUE
	##	3	0	1	0	0	falciformis_uninfected	FALSE
	##	4	16	1	60	150000	falciformis_ferrisi	TRUE

## 5	0	1	0	0	falciformis_uninfected	TRUE
## 6	0	1	0	0	falciformis_uninfected	TRUE
## 7	6	1	27	67500	falciformis_ferrisi	TRUE
## 8	0	1	2	5000	falciformis_ferrisi	TRUE
## 9	8	1	31	77500	falciformis_ferrisi	TRUE
## 10	20	1	87	217500	falciformis_ferrisi	TRUE
## 11	0	1	0	0	falciformis_uninfected	TRUE
## 12	1	1	1	2500	falciformis_ferrisi	TRUE
## 13	0	1	1	2500	falciformis_uninfected	TRUE
## 14	2	1	4	10000	falciformis_ferrisi	TRUE
## 15	1	1	3	7500	falciformis_ferrisi	TRUE
## 16	0	1	0	0	falciformis_uninfected	TRUE
## 17	0	1	0	0	falciformis_uninfected	FALSE
## 18	8	1	37	92500	falciformis_ferrisi	TRUE
## 19	0	1	0	0	falciformis_uninfected	FALSE
## 20	1	1	7	17500	falciformis_ferrisi	TRUE
## 21	6	1	17	42500	ferrisi_ferrisi	TRUE
## 22	0	1	3	7500	ferrisi_ferrisi	FALSE
## 23	0	1	0	0	ferrisi_ferrisi	FALSE
## 24	0	1	0	0	ferrisi_uninfected	FALSE
## 25	0	1	1	2500	ferrisi_ferrisi	FALSE
## 26	7	1	20	50000	ferrisi_ferrisi	FALSE
## 27	0	1	0	0	ferrisi_uninfected	FALSE
## 28	1	1	1	2500	ferrisi_ferrisi	FALSE
## 29	0	1	0	0	ferrisi_uninfected	FALSE
## 30	0	1	0	0	ferrisi_uninfected	FALSE
## 31	0	1	0	0	ferrisi_ferrisi	TRUE
## 32	0	1	0	0	ferrisi_ferrisi	FALSE
## 33	0	1	0	0	ferrisi_uninfected	FALSE
## 34	0	1	0	0	ferrisi_uninfected	FALSE
## 35	0	1	0	0	ferrisi_uninfected	FALSE
## 36	0	1	0	0	ferrisi_uninfected	FALSE
## 37	0	1	0	0	ferrisi_uninfected	FALSE
## 38	0	1	0	0	ferrisi_uninfected	FALSE
## 39	0	1	0	0	ferrisi_uninfected	FALSE
## 40	0	1	2	5000	ferrisi_ferrisi	TRUE
## 41	0	1	0	0	ferrisi_ferrisi	TRUE
## 42	0	1	0	0	ferrisi_uninfected	FALSE
## 43	0	1	0	0	ferrisi_uninfected	FALSE
## 44	0	1	1	2500	ferrisi_ferrisi	TRUE
## 45	13	1	48	120000	ferrisi_ferrisi	TRUE
## 46	0	1	0	0	ferrisi_uninfected	FALSE
## 47	1	1	1	2500	ferrisi_ferrisi	TRUE
## 48	0	1	0	0	ferrisi_uninfected	FALSE
## 49	0	1	0	0	ferrisi_uninfected	FALSE
## 51	0	1	0	0	ferrisi_uninfected	FALSE
## 52	0	1	0	0	ferrisi_uninfected	FALSE
## 53	6	1	15	37500	ferrisi_ferrisi	TRUE
## 54	0	1	0	0	falciformis_falciformis	TRUE
## 55	NA	NA	NA	NA	falciformis_ferrisi	TRUE
## 56	0	1	0	0	falciformis_uninfected	FALSE
## 57	0	1	0	0	falciformis_uninfected	FALSE
## 58	NA	NA	NA	NA	falciformis_ferrisi	TRUE
## 62	0	1	0	0	ferrisi_uninfected	FALSE

## 64	NA	NA	NA	NA	ferrisi_ferrisi	TRUE
## 65	0	1	0	0	ferrisi_uninfected	FALSE
## 66	NA	NA	NA	NA	uninfected_falciformis	TRUE
## 67	NA	NA	NA	NA	uninfected_ferrisi	TRUE
## 68	0	1	0	0	uninfected	TRUE
## 69	1	1	3	7500	falciformis_falciformis	TRUE
## 70	47	1	181	452500	ferrisi_falciformis	TRUE
## 71	47	1	181	452500	ferrisi_falciformis	TRUE
## 72	71	1	277	692500	ferrisi_falciformis	TRUE
## 73	71	1	277	692500	ferrisi_falciformis	TRUE
## 74	0	1	0	0	ferrisi_ferrisi	FALSE
## 75	0	1	0	0	ferrisi_ferrisi	FALSE
## 76	0	1	0	0	ferrisi_uninfected	FALSE
## 77	0	1	0	0	ferrisi_uninfected	FALSE
## 78	0	1	0	0	falciformis_falciformis	TRUE
## 79	0	1	0	0	falciformis_falciformis	TRUE
## 80	0	1	0	0	falciformis_falciformis	TRUE
## 81	0	1	0	0	falciformis_falciformis	TRUE
## 82	0	1	6	15000	falciformis_ferrisi	TRUE
## 83	0	1	6	15000	falciformis_ferrisi	TRUE
## 84	0	1	0	0	falciformis_uninfected	FALSE
## 85	0	1	0	0	falciformis_uninfected	FALSE
## 86	0	1	3	7500	falciformis_falciformis	TRUE
## 87	0	1	3	7500	falciformis_falciformis	TRUE
## 88	0	1	0	0	falciformis_uninfected	FALSE
## 89	0	1	0	0	falciformis_uninfected	FALSE
## 90	19	1	82	205000	uninfected_falciformis	TRUE
## 91	19	1	82	205000	uninfected_falciformis	TRUE
## 92	0	1	0	0	uninfected_falciformis	TRUE
## 93	0	1	0	0	uninfected_falciformis	TRUE
## 94	37	1	152	380000	uninfected_ferrisi	TRUE
## 95	0	1	0	0	uninfected	FALSE
## 96	0	1	0	0	uninfected	FALSE
## 97	0	1	0	0	ferrisi_ferrisi	TRUE
## 98	0	1	0	0	ferrisi_ferrisi	FALSE
## 99	2	1	6	15000	ferrisi_ferrisi	TRUE
## 100	35	1	175	437500	ferrisi_falciformis	TRUE
## 101	4	1	14	35000	ferrisi_falciformis	TRUE
## 102	15	1	67	167500	ferrisi_falciformis	TRUE
## 103	0	1	0	0	ferrisi_uninfected	FALSE
## 104	0	1	0	0	ferrisi_uninfected	FALSE
## 105	0	1	0	0	ferrisi_uninfected	TRUE
## 106	2	1	5	12500	falciformis_falciformis	TRUE
## 107	0	1	0	0	falciformis_ferrisi	TRUE
## 108	0	1	0	0	falciformis_uninfected	TRUE
## 110	0	1	0	0	uninfected	FALSE
## 111	0	1	0	0	uninfected	FALSE
## 112	0	1	0	0	uninfected	FALSE
## 113	1	1	4	10000	uninfected_ferrisi	FALSE
## 114	18	1	82	205000	uninfected_ferrisi	TRUE
## 115	105	1	398	995000	uninfected_falciformis	TRUE
## 116	36	1	140	350000	uninfected_falciformis	TRUE
## 117	0	1	0	0	ferrisi_ferrisi	TRUE
## 118	0	1	0	0	ferrisi_ferrisi	TRUE

## 119	0	1	0	0		uninfected	FALSE
## 120	0	1	0	0		uninfected	FALSE
## 121	2	1	7	17500		uninfected_ferrisi	TRUE
## 122	2	1	7	17500		uninfected_ferrisi	TRUE
## 123	0	1	0	0		ferrisi_ferrisi	TRUE
## 124	0	1	0	0		ferrisi_ferrisi	TRUE
## 125	0	1	4	10000	uninfected_falciformis		TRUE
## 126	0	1	0	0		uninfected_ferrisi	TRUE
## 127	0	1	0	0		uninfected_ferrisi	TRUE
## 128	9	1	24	60000	ferrisi_falciformis		TRUE
## 129	9	1	24	60000	ferrisi_falciformis		TRUE
## 130	3	1	6	15000		ferrisi_ferrisi	TRUE
## 131	3	1	6	15000		ferrisi_ferrisi	TRUE
## 132	11	1	62	155000	ferrisi_falciformis		TRUE
## 133	11	1	62	155000	ferrisi_falciformis		TRUE
## 134	4	1	6	15000		uninfected_ferrisi	TRUE
## 135	4	1	6	15000		uninfected_ferrisi	TRUE
## 136	0	1	0	0	ferrisi_uninfected		TRUE
## 137	0	1	0	0	ferrisi_uninfected		TRUE
## 138	0	1	1	2500		uninfected_ferrisi	TRUE
## 139	0	1	1	2500		uninfected_ferrisi	TRUE
## 140	0	1	4	10000	ferrisi_falciformis		TRUE
## 141	0	1	4	10000	ferrisi_falciformis		TRUE
## 142	0	1	0	0	falciformis_falciformis		TRUE
## 143	0	1	0	0	falciformis_falciformis		TRUE
## 144	NA	NA	NA	NA	uninfected_ferrisi		TRUE
## 145	2	1	13	32500	ferrisi_falciformis		TRUE
## 146	2	1	13	32500	ferrisi_falciformis		TRUE
## 147	0	1	0	0	ferrisi_uninfected		FALSE
## 148	0	1	0	0	ferrisi_uninfected		FALSE
## 149	0	1	0	0		uninfected	FALSE
## 150	0	1	0	0		uninfected	FALSE
## 151	0	1	0	0	falciformis_uninfected		FALSE
## 152	0	1	0	0	falciformis_uninfected		FALSE
## 153	0	1	0	0	falciformis_ferrisi		TRUE
## 154	0	1	0	0	falciformis_ferrisi		TRUE
## 155	NA	NA	NA	NA	falciformis_ferrisi		TRUE
## 156	0	1	0	0		uninfected	FALSE
## 157	0	1	0	0		uninfected	FALSE
## 158	0	1	0	0	ferrisi_ferrisi		TRUE
## 159	0	1	0	0	ferrisi_ferrisi		TRUE
## delta_ct_cewe_MminusE		IFNy_CEWE	IFNy_MES	IRG6	IL.12	CASP1	
## 1	-5.7900000	54.4201293		NA	-4.425000	-9.130000	22.02920
## 2	-5.9100000	84.9852125		NA	-4.392500	-6.932500	24.25054
## 3	-7.1200000	11.9382982		NA	-3.122500	-4.647500	22.55511
## 4	-5.1600000	37.5056013		NA	-4.312500	-6.857500	27.50341
## 5	-6.2200000	21.8877741		NA	-3.010000	-5.435000	25.45624
## 6	-5.9700000	81.6629906		NA		-6.122500	23.14097
## 7	-7.8900000	112.0556441		NA	-1.042500	-4.827500	23.11127
## 8	-5.8400000	53.5403908		NA	-3.027500	-5.597500	25.06357
## 9	-6.0200000	121.1053913		NA	-2.042500	-5.092500	22.45011
## 10	-4.4200000	61.4115394		NA	-4.337500	-6.392500	23.55407
## 11	-6.7600000	25.0601964		NA	-6.939167	-5.692500	23.81598
## 12	-6.6500000	43.3808824		NA	-2.455000	-5.660000	22.70095

## 13	-4.6800000	15.7742980	NA	-3.952500	-6.082500	22.49518
## 14	-6.9200000	31.9834136	NA	NA	NA	NA
## 15	-5.9600000	25.5475920	NA	-4.147500	-6.652500	22.84267
## 16	-4.7300000	1.7194288	NA	-4.365000	-6.470000	22.04784
## 17	-8.4800000	23.1158022	NA	NA	NA	23.38067
## 18	-2.7300000	87.5850374	NA	-3.245000	-6.495000	23.42149
## 19	-8.9000000	14.6139890	NA	-2.137500	-4.062500	22.85872
## 20	-6.9300000	21.2530815	NA	-3.450000	-5.385000	23.05298
## 21	-5.7500000	22.5199588	NA	-2.285000	-5.855000	22.51961
## 22	-8.0000000	41.1760044	NA	-3.070000	-5.270000	NA
## 23	-11.9000000	11.2982790	NA	-3.910000	-6.305000	22.76425
## 24	-5.9000000	22.7925982	NA	-6.357500	-9.977500	24.16598
## 25	-10.0600000	0.2251453	NA	-5.502500	-7.702500	23.57993
## 26	-8.3800000	15.5470128	NA	-12.735000	-6.165000	NA
## 27	-10.0200000	12.6543617	NA	-1.047500	-4.912500	23.76993
## 28	-11.4200000	24.5913140	NA	-15.332500	-6.567500	22.86814
## 29	-8.2500000	1.0402825	NA	0.862500	-4.067500	22.86023
## 30	-8.1500000	22.2297969	NA	-8.365000	-12.480000	28.45142
## 31	-7.9100000	28.0476365	NA	-13.027500	-3.817500	22.69451
## 32	-9.7500000	19.7264529	NA	-5.455000	-8.010000	24.16373
## 33	-9.2000000	11.5962496	NA	-4.755000	-8.220000	21.79801
## 34	-10.5500000	NA	NA	-6.865000	-9.900000	23.41526
## 35	-10.4200000	16.5237750	NA	-3.427500	-6.162500	23.28426
## 36	4.1400000	6.0570706	NA	-3.140000	-5.230000	25.19149
## 37	-10.6100000	37.2475523	NA	-3.740000	-6.190000	21.63034
## 38	-10.3900000	14.6670412	NA	-3.945000	-6.145000	23.74273
## 39	-10.9900000	27.8926078	NA	-5.355000	-8.825000	20.93711
## 40	-9.1800000	8.4130370	NA	-12.047500	-8.652500	24.43256
## 41	-7.1200000	54.1465789	NA	-3.255000	-5.190000	29.98603
## 42	-12.6900000	23.3076495	NA	-11.830000	-5.850000	24.28977
## 43	-10.5700000	33.8222754	NA	-2.852500	-5.162500	22.78772
## 44	-6.1900000	48.3675947	NA	-2.342500	-4.142500	22.53197
## 45	-3.1100000	52.2081652	NA	NA	-5.265000	24.20202
## 46	-9.2100000	19.5159266	NA	-1.420000	-4.235000	23.79661
## 47	-6.3400000	52.3669479	NA	19.702500	NA	23.59150
## 48	-8.7900000	32.5857552	NA	-5.495000	-8.070000	25.16027
## 49	-9.1800000	11.1755693	NA	-3.315000	-7.370000	20.43007
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## 153 15.14489 22.14929 15.490731 21.16589 24.41267 23.00500 17.08754 22.09470
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## 158 17.73318 21.05519 16.366598 22.02264 23.21401 24.41094 18.40590 27.11805
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## 3 7.810604 NA 7.749293 12.871210 20.059938 23.96486 14.494109
## 4 10.157602 27.67628 7.183272 14.041496 15.618948 23.45405 10.907114
## 5 9.241544 NA 9.869590 14.371520 17.538455 24.12714 13.634454
## 6 9.197374 24.94612 8.225922 11.583533 20.053889 25.43377 14.403728
## 7 8.600942 24.90775 8.730690 11.900492 18.177256 23.25482 14.544612
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## 10 9.052160 27.46451 8.642571 10.342714 14.618691 21.39968 9.414350
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## 14 NA NA NA NA NA NA NA NA
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## 134 10.745571 18.11004 9.538819 10.048293 10.673092 NA 17.197486
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## 142 9.496184 20.05410 7.969417 8.572635 9.429172 23.67079 12.798479

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## 158 8.701905 20.94546 7.665722 8.340444 9.444841 24.42321 16.724064
## 159 8.701905 20.94546 7.665722 8.340444 9.444841 24.42321 16.724064
##          PRF1      RETNLB      SOCS1      TICAM1      TNF      IL.17A      GAPDH      IL.13
## 1    27.53290 11.389996 13.025961 19.82281 21.01065      NA      NA      NA
## 2    26.26383  7.857130 10.292493 17.66099 22.36282 27.31730      NA      NA
## 3      NA  9.184355  9.205008 19.11736 22.81213 22.76158      NA      NA
## 4   23.24062  3.920192 10.692568 15.46167 18.96024 23.59277      NA      NA
## 5   27.09015  8.711133 10.586118 17.03506 24.77639 27.66435      NA      NA
## 6   27.84301 15.803676 10.037031 18.92915 25.01909 28.88865      NA      NA
## 7   23.54348 11.930951 10.137282 17.89026 20.40686      NA      NA      NA
## 8   28.00436 10.795116 10.187464 17.98634 21.91510 26.90213      NA      NA
## 9      NA 11.763447  9.833251 20.04689 25.99834 29.39321      NA      NA
## 10  20.45141  4.079604 11.242170 15.12650 18.21831 23.50087      NA      NA
## 11      NA 12.512554  8.390115 17.00279 24.39284 27.71849      NA      NA
## 12  21.01384  3.598778  8.892853 14.34632 18.18376 24.03781      NA      NA
## 13  25.10224 11.645965 10.674034 15.64940 20.93638 25.66384      NA      NA
## 14      NA      NA      NA      NA      NA      NA      NA      NA
## 15  27.17679 12.534258 11.718299 17.56715 20.51972 23.02245      NA      NA
## 16  24.64252 11.212956 10.034478 16.84957 22.49043 25.13329      NA      NA
## 17  22.71284  6.937463 10.044808 15.08446 17.05868 29.06355      NA      NA
## 18  26.20900  5.973854 10.589004 17.65482 19.35511 21.39723      NA      NA
## 19  25.66098 14.362461 10.790189 18.71333 23.10196 24.22595      NA      NA
## 20      NA  5.662282 10.323638 15.91257 19.63243 24.44564      NA      NA
## 21  23.09671  6.708141  9.097796 16.83769 19.32845 27.21590      NA      NA
## 22      NA      NA      NA      NA      NA      NA      NA      NA
## 23  25.16968  8.373846 10.727382 15.39051 19.76802      NA      NA      NA
## 24  22.09717  3.437346 10.438836 13.27494 18.82194 27.67691      NA      NA
## 25  22.59840  4.203089  9.684278 13.27406 22.08087 17.21984      NA      NA
## 26  24.78750  4.605416 10.017204 15.04402 23.69131 25.87087      NA      NA
## 27  25.69449  9.644582 12.041930 19.34746 26.10923      NA      NA      NA
## 28  26.11614  6.063100  9.980612 14.75829 18.44981 23.57426      NA      NA
## 29      NA 12.795983  9.838008 22.32244 29.87482 24.34957      NA      NA
## 30  28.71924 13.919183 15.560557 16.95622 20.43844      NA      NA      NA
## 31  29.16415  9.982388  9.482890 14.86344 21.08135 24.11874      NA      NA
## 32  21.10798  5.917482 11.194286 13.04953 16.84558 22.43741      NA      NA
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## 34  29.53929 10.842803 12.155859 17.76277 21.50840      NA      NA      NA
## 35  25.38933 11.824440  9.660671 15.41369 20.83225 24.01816      NA      NA
## 36  25.56295  7.036342  8.830993 15.62009 20.40643 25.94759      NA      NA

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## 37	NA	12.132540	9.535813	16.56348	22.45497	NA	NA	NA
## 38	NA	9.879838	11.097173	16.94929	24.08582	NA	NA	NA
## 39	21.14482	8.466972	12.429422	15.73371	16.46384	23.22126	NA	NA
## 40	18.08027	3.785109	10.974022	12.41300	13.78664	20.40108	NA	NA
## 41	24.78306	5.259263	10.307205	14.37050	19.70445	24.74768	NA	NA
## 42	NA	11.495341	11.487913	16.29785	20.60002	22.43801	NA	NA
## 43	NA	7.758496	11.493739	17.45863	22.01304	29.55073	NA	NA
## 44	29.51591	9.225770	9.632405	17.44476	21.63822	24.71555	NA	NA
## 45	20.38618	4.346449	11.657992	15.33566	15.86004	18.20036	NA	NA
## 46	28.11725	9.187486	10.970666	19.30253	21.39020	26.03227	NA	NA
## 47	21.15985	4.867295	11.106637	15.25927	16.16250	21.86356	NA	NA
## 48	21.54708	3.690941	10.228503	13.47368	18.09514	29.17745	NA	NA
## 49	23.41759	8.189116	10.139407	15.24493	17.65270	24.21543	NA	NA
## 51	NA	NA	NA	NA	NA	NA	NA	NA
## 52	25.89262	4.204721	10.569843	12.91764	17.50383	24.76340	NA	NA
## 53	19.92611	3.577107	10.324091	14.54200	16.01331	19.44051	NA	NA
## 54	26.01465	10.749170	11.024760	21.19794	21.01304	25.25417	NA	NA
## 55	27.09819	9.755923	10.478270	22.50241	21.56508	28.39958	NA	NA
## 56	27.12899	10.841208	12.989070	16.99448	20.03119	24.29158	NA	NA
## 57	27.18535	9.478791	10.607035	21.82549	21.98348	27.18482	NA	NA
## 58	25.41207	12.030827	13.123553	21.09282	21.07389	21.40125	NA	NA
## 62	21.79024	9.145387	10.833533	15.29784	19.01250	24.39017	NA	NA
## 64	26.41866	9.278296	11.303618	21.34152	21.31616	26.73246	NA	NA
## 65	25.29939	9.923647	11.828319	19.06670	21.78523	NA	NA	NA
## 66	NA	8.262385	8.890513	20.80948	23.70044	NA	NA	NA
## 67	25.11673	9.047844	11.867247	16.30778	18.36694	22.32878	NA	NA
## 68	28.88317	9.635853	12.837053	19.15818	22.89580	25.95189	NA	NA
## 69	23.85662	9.703631	11.627023	21.52452	22.65241	27.28047	NA	NA
## 70	NA	18.572389	8.318661	29.57724	23.13135	25.03445	NA	NA
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## 72	NA	17.913556	10.084373	25.58661	NA	NA	NA	NA
## 73	NA	17.913556	10.084373	25.58661	NA	NA	NA	NA
## 74	27.59474	20.897073	9.482244	24.73153	27.59754	27.80751	NA	NA
## 75	27.59474	20.897073	9.482244	24.73153	27.59754	27.80751	NA	NA
## 76	NA	16.332964	9.665532	21.42768	23.91542	26.29502	NA	NA
## 77	NA	16.332964	9.665532	21.42768	23.91542	26.29502	NA	NA
## 78	NA	9.493187	11.330597	26.12898	26.67485	26.83890	NA	NA
## 79	NA	9.493187	11.330597	26.12898	26.67485	26.83890	NA	NA
## 80	NA	14.714598	8.041715	24.10520	28.93255	28.74184	NA	NA
## 81	NA	14.714598	8.041715	24.10520	28.93255	28.74184	NA	NA
## 82	25.43324	20.720319	7.087203	26.26861	27.69078	24.88612	NA	NA
## 83	25.43324	20.720319	7.087203	26.26861	27.69078	24.88612	NA	NA
## 84	NA	10.975465	9.162248	19.60484	29.13404	24.18267	NA	NA
## 85	NA	10.975465	9.162248	19.60484	29.13404	24.18267	NA	NA
## 86	NA	22.021335	13.581984	NA	28.37664	NA	NA	NA
## 87	NA	22.021335	13.581984	NA	28.37664	NA	NA	NA
## 88	26.78273	13.342864	8.919463	19.84097	25.19713	25.20945	NA	NA
## 89	26.78273	13.342864	8.919463	19.84097	25.19713	25.20945	NA	NA
## 90	26.69613	20.083060	7.158283	23.30618	28.17372	26.81986	NA	NA
## 91	26.69613	20.083060	7.158283	23.30618	28.17372	26.81986	NA	NA
## 92	28.62742	22.004654	8.871887	23.74250	28.31769	25.16803	NA	NA
## 93	28.62742	22.004654	8.871887	23.74250	28.31769	25.16803	NA	NA
## 94	26.19344	9.526062	11.755902	21.52548	20.79691	25.44602	NA	NA
## 95	28.89657	18.031914	9.895583	25.98677	NA	26.98194	NA	NA

```

## 96 28.89657 18.031914 9.895583 25.98677      NA 26.98194      NA      NA
## 97 29.79103 15.178442 10.393341 22.46358 27.50077 28.02264      NA      NA
## 98 25.55363 9.661429 12.013956 18.22035 19.84642 26.38589      NA      NA
## 99 24.21456 8.805372 11.222371 20.81727 19.51511 22.68459      NA      NA
## 100      NA 16.855267 8.065261 20.60755 23.72752      NA      NA      NA
## 101 26.21215 9.441200 11.032251 20.47256 20.23849 23.74437      NA      NA
## 102 23.15837 9.722345 12.451737 20.65242 17.12110 22.29789      NA      NA
## 103 26.79236 13.220426 14.919748 20.57782 22.50920 25.33117      NA      NA
## 104 27.50508 10.058471 12.308402 22.04861 23.31357 25.23458      NA      NA
## 105 24.06304 10.004453 11.728596 24.10621 21.72844 26.79136      NA      NA
## 106 23.62678 9.365788 11.073955 17.51909 19.97281 27.93933      NA      NA
## 107 23.77440 9.192797 11.689073 18.09591 20.75239 29.78785      NA      NA
## 108 23.93945 15.923781 7.757090 27.17214 25.43076 25.57618 2.748428 24.65534
## 110 25.88464 11.281775 12.009186 21.10553 22.98131 23.67780 5.193404 18.29073
## 111      NA 10.982572 12.330284 20.82249 21.80276 25.19757 5.124103 20.04791
## 112      NA 10.944685 11.589537 23.26258 20.96380 23.87070 4.732154 21.35713
## 113 27.10505 8.885230 11.076750 16.22269 18.16059 21.48596 3.773862 15.43664
## 114 24.29967 10.008384 10.705349 22.69601 20.23189 23.14650 3.883404 17.92247
## 115      NA 10.995071 10.401308 20.49431 21.47300 26.50184 3.781868 18.98706
## 116 19.06725 7.547668 11.758377 17.68614 16.26408 20.58902 4.826666 14.23954
## 117 25.49845 9.999622 9.756697 21.55859 21.56077 23.34107 3.288691 19.69519
## 118 25.49845 9.999622 9.756697 21.55859 21.56077 23.34107 3.288691 19.69519
## 119 26.64396 9.906633 10.453336 22.37117 22.84888 22.98972 3.764242 20.64206
## 120 26.64396 9.906633 10.453336 22.37117 22.84888 22.98972 3.764242 20.64206
## 121 28.07379 9.665312 9.605007 20.07661 20.12716 24.11843 3.583590 17.74507
## 122 28.07379 9.665312 9.605007 20.07661 20.12716 24.11843 3.583590 17.74507
## 123 23.49281 9.661908 9.225406 21.56845 22.03168 23.95907 3.530609 19.52374
## 124 23.49281 9.661908 9.225406 21.56845 22.03168 23.95907 3.530609 19.52374
## 125 23.94627 12.576263 12.867410 20.08692 20.32090 27.45492 6.323172 17.34487
## 126 24.18033 11.724569 10.427714 27.52816 26.40631 26.25363 4.399915 22.61048
## 127 24.18033 11.724569 10.427714 27.52816 26.40631 26.25363 4.399915 22.61048
## 128 23.92448 7.985537 9.284697 19.19948 18.33022 24.26162 3.236068 16.52889
## 129 23.92448 7.985537 9.284697 19.19948 18.33022 24.26162 3.236068 16.52889
## 130 28.09646 5.846103 10.089456 18.04099 19.42994 22.77294 4.566144 15.64012
## 131 28.09646 5.846103 10.089456 18.04099 19.42994 22.77294 4.566144 15.64012
## 132 22.17432 8.544338 9.708748 19.40001 18.85483 23.09182 3.565913 15.96387
## 133 22.17432 8.544338 9.708748 19.40001 18.85483 23.09182 3.565913 15.96387
## 134 25.97794 11.387807 11.285548 22.13123 21.26313 24.48532 5.064094 19.78487
## 135 25.97794 11.387807 11.285548 22.13123 21.26313 24.48532 5.064094 19.78487
## 136      NA 10.488427 11.445105 22.62902 25.72357 26.97360 4.605335 23.10120
## 137      NA 10.488427 11.445105 22.62902 25.72357 26.97360 4.605335 23.10120
## 138      NA      NA      NA      NA      NA      NA      NA      NA
## 139      NA      NA      NA      NA      NA      NA      NA      NA
## 140 22.26847 10.541307 9.678177 16.57747 17.42194 23.16217 3.620965 14.96183
## 141 22.26847 10.541307 9.678177 16.57747 17.42194 23.16217 3.620965 14.96183
## 142 24.50357 8.477857 10.166476 17.26136 17.46136 23.57394 4.168857 15.84020
## 143 24.50357 8.477857 10.166476 17.26136 17.46136 23.57394 4.168857 15.84020
## 144 23.04488 10.740533 11.861010 20.43164 17.80555 26.62705 5.525789 16.83008
## 145 22.51975 10.484425 12.108359 20.85134 16.34527 23.47938 5.455238 15.73607
## 146 22.51975 10.484425 12.108359 20.85134 16.34527 23.47938 5.455238 15.73607
## 147 25.18772 11.220518 9.548208 22.43535 22.25967 25.85111 3.645127 21.41995
## 148 25.18772 11.220518 9.548208 22.43535 22.25967 25.85111 3.645127 21.41995
## 149 24.28532 10.960531 8.968065 23.16068 23.48999 23.41591 3.068848 21.10862
## 150 24.28532 10.960531 8.968065 23.16068 23.48999 23.41591 3.068848 21.10862

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## 151 24.24964 10.019037 8.531568 21.37614 20.82249 22.83479 2.998611 20.67509
## 152 24.24964 10.019037 8.531568 21.37614 20.82249 22.83479 2.998611 20.67509
## 153      NA 8.590075 8.871211 17.57769 19.73392 23.30303 3.760593 16.81424
## 154      NA 8.590075 8.871211 17.57769 19.73392 23.30303 3.760593 16.81424
## 155 20.88617 6.927890 13.408973 17.53509 16.57800 25.73077 6.531429 14.49658
## 156 28.46406 10.098975 10.393635 23.04097 22.15808 23.81269 3.633117 20.31023
## 157 28.46406 10.098975 10.393635 23.04097 22.15808 23.81269 3.633117 20.31023
## 158 27.33021 10.388094 8.474758 19.93831 21.28205 25.62297 2.765972 20.25871
## 159 27.33021 10.388094 8.474758 19.93831 21.28205 25.62297 2.765972 20.25871
##   Position    CD4   Treg Div_Treg Treg17     Th1 Div_Th1 Th17 Div_Th17    CD8
## 1       mLN 44.900  6.385  16.205 13.520  6.780  71.200 0.890  46.875 14.390
## 2       mLN 46.145  7.005  21.365 11.565 10.920  75.115 1.075  42.390 13.840
## 3       mLN 56.220  7.150  12.455  9.505  2.965  19.840 1.630  30.055 10.020
## 4       mLN 40.590  6.450  23.760 12.780  9.250  81.210 1.705  78.305 25.305
## 5       mLN 52.245  8.695  13.465 14.400  2.545  27.850 1.060  27.445 17.550
## 6       mLN 46.895  6.890  13.355  7.035  2.900  25.520 0.695  32.195  7.490
## 7       mLN 49.470  6.065  24.795 13.950  6.870  76.515 1.110  65.735  9.065
## 8       mLN 45.740  6.520  17.115  8.645  9.585  51.870 1.090  40.600 13.995
## 9       mLN 46.330  6.465  21.000 14.540  7.020  67.360 1.615  65.055  8.840
## 10      mLN 43.325  8.915  13.090  6.825  7.710  79.020 1.185  55.835 26.505
## 11      mLN 68.010  3.630  14.110 14.350  1.730  14.310 0.925  33.075 13.900
## 12      mLN 37.435  9.045  20.515  9.260  9.100  64.370 0.805  49.910 31.115
## 13      mLN 53.250  6.895  7.850  9.015  2.505  19.190 0.945  28.815 18.080
## 14      mLN 43.090  6.120  21.885 25.480  7.620  60.780 1.415  45.325 16.055
## 15      mLN 47.340  6.465  16.775 13.315  4.840  54.635 0.970  35.275 19.235
## 16      mLN 61.525  5.650  12.710  9.660  1.875  29.575 0.535  21.155 17.080
## 17      mLN 51.475  6.690  12.110  7.535  1.455  21.435 0.550  22.920 28.360
## 18      mLN 36.155  8.875  24.110  8.970 11.540  90.780 4.050  67.780 24.175
## 19      mLN 54.575  5.110  13.005  9.130  1.835  22.300 1.075  30.890 11.410
## 20      mLN 58.920  5.075  16.575 15.280  4.445  48.205 0.795  28.355 17.805
## 21      mLN 49.925  7.915  15.795  4.280  3.710  75.720 0.765  46.720 33.620
## 22      mLN 43.270  7.155  16.365 10.450  5.485  65.425 1.170  29.270 10.565
## 23      mLN 53.240  5.215  41.605 11.280  6.795  59.590 1.225  36.960 12.140
## 24      mLN 49.350  9.015  8.260  4.370  1.535  22.665 0.580  19.230 26.665
## 25      mLN 28.295 27.230  38.210  8.875  5.925  65.700 1.935  41.455 35.575
## 26      mLN 53.270  6.670  23.525  7.885  3.540  53.200 1.360  24.045 17.865
## 27      mLN 54.265  9.475  10.550  4.220  1.425  22.075 1.070  31.665 27.880
## 28      mLN 48.490  5.220  36.585 17.105  3.370  72.075 0.620  38.040 27.135
## 29      mLN 56.780  4.835  16.835 13.005  1.735  11.910 1.120  50.070 18.020
## 30      mLN 67.430  3.900  13.000 12.720  1.855  13.035 1.440  19.120 14.640
## 31      mLN 53.510  4.525  30.580 17.135  5.615  41.680 0.975  22.355  7.365
## 32      mLN 49.935  6.265  43.855 12.800  5.395  56.130 0.875  30.460 13.720
## 33      mLN 42.860  8.465  8.225 10.045  1.780  31.145 1.110  63.235 20.855
## 34      mLN 55.305  7.315  22.150 12.340  1.835  34.180 1.010  12.905 12.335
## 35      mLN 52.100  5.205  31.795 18.210  2.740  21.990 0.730  27.275 18.260
## 36      mLN 48.705 11.315  19.245  7.590  3.110  35.555 1.435  39.995 26.645
## 37      mLN 42.070  5.530  31.595  9.750  3.055  29.220 0.840  30.170  7.725
## 38      mLN 55.005  4.635  17.730 12.165  1.510  28.170 0.660  9.700 21.500
## 39      mLN 55.135  4.955  19.550  6.445  1.305  27.140 0.485  19.200 27.155
## 40      mLN 48.920 14.300  52.620 14.605  7.425  79.505 1.730  69.700 21.090
## 41      mLN 60.705  3.740  36.475 18.505  5.280  48.670 1.940  24.220 18.575
## 42      mLN 49.850  4.700  26.940  8.940  3.020  22.305 1.400  21.805 10.375
## 43      mLN 53.755  9.235  19.495  6.415  1.375  27.520 0.830  28.285 29.465
## 44      mLN 48.380  6.965  36.775  9.390  4.130  60.855 0.680  27.710 24.340

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## 45	mLN	46.695	9.310	34.995	6.330	2.810	76.265	0.635	46.690	28.860
## 46	mLN	58.170	7.095	12.905	5.325	1.330	22.600	0.630	23.055	33.330
## 47	mLN	50.800	9.805	35.235	8.230	5.480	76.185	1.430	59.040	34.585
## 48	mLN	57.615	5.520	13.720	5.700	1.235	29.350	0.590	20.910	32.530
## 49	mLN	67.755	3.245	22.775	17.040	1.835	15.255	1.080	12.220	14.995
## 51	mLN	54.710	7.000	17.570	9.180	1.315	26.475	0.925	25.815	26.945
## 52	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 53	mLN	48.125	10.595	33.980	5.645	4.170	58.705	0.520	39.065	28.025
## 54	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 55	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 56	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 57	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 58	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 62	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 64	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 65	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 66	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 67	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 68	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 69	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 70	Spleen	13.200	19.100	22.500	1.810	10.600	37.200	1.350	37.000	6.110
## 71	mLN	14.600	14.000	26.700	7.630	8.130	60.600	3.700	62.100	6.580
## 72	mLN	17.900	11.800	34.500	11.500	13.100	63.500	3.160	64.200	9.980
## 73	Spleen	12.300	15.900	31.000	2.470	17.500	47.500	1.790	33.000	5.020
## 74	mLN	27.200	11.500	25.600	9.050	4.780	54.900	2.170	42.700	8.930
## 75	Spleen	14.000	16.100	27.900	3.360	20.800	43.900	1.930	42.000	5.890
## 76	mLN	52.600	14.400	8.070	3.230	4.830	15.800	1.530	13.300	15.400
## 77	Spleen	13.700	15.600	20.200	2.130	15.100	14.700	1.380	12.400	4.290
## 78	Spleen	16.300	20.500	21.400	2.740	18.000	47.700	2.440	48.800	4.880
## 79	mLN	28.400	15.200	24.900	8.360	11.600	54.600	3.030	43.800	7.770
## 80	mLN	20.300	11.100	30.600	12.100	6.870	63.100	3.790	65.800	5.870
## 81	Spleen	17.900	15.900	29.400	3.730	11.800	46.900	2.960	58.900	4.590
## 82	mLN	25.400	12.000	23.200	9.410	9.080	49.700	2.060	52.400	6.140
## 83	Spleen	18.300	20.200	23.100	3.910	28.100	48.400	3.620	59.400	4.400
## 84	mLN	31.500	17.500	13.600	17.500	5.730	19.400	2.350	12.400	14.700
## 85	Spleen	18.200	16.000	20.200	4.450	14.300	13.800	1.530	9.690	9.240
## 86	Spleen	15.800	21.500	21.900	3.680	19.500	46.400	1.900	53.600	7.310
## 87	mLN	14.700	18.900	30.000	20.000	12.400	58.700	3.030	58.000	7.300
## 88	mLN	37.700	7.470	21.600	10.500	2.700	27.500	1.510	54.300	10.500
## 89	Spleen	22.900	9.730	26.100	4.330	10.600	16.200	1.520	33.600	5.260
## 90	mLN	25.300	7.830	41.200	8.040	6.850	83.700	1.190	73.900	7.560
## 91	Spleen	15.300	14.700	28.100	1.920	13.600	50.600	1.010	39.200	4.060
## 92	mLN	28.300	16.700	45.100	5.680	7.260	70.200	1.450	47.700	5.790
## 93	Spleen	29.300	28.700	19.500	1.250	16.900	55.000	2.350	2.310	2.450
## 94	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 95	Spleen	21.200	18.200	14.900	2.220	7.110	12.200	0.790	12.100	5.170
## 96	mLN	45.400	16.100	6.480	3.430	3.260	12.600	1.000	9.200	11.500
## 97	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 98	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 99	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 100	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 101	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 102	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 103	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA

## 104	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 105	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 106	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 107	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 108	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 110	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 111	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 112	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 113	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 114	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 115	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 116	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 117	Spleen	27.200	5.900	19.300	4.270	4.400	21.700	0.920	19.200	6.860	
## 118	mLN	55.900	6.210	26.400	17.500	5.010	44.100	1.470	29.700	14.400	
## 119	Spleen	36.000	5.160	22.100	4.980	4.950	22.500	1.080	17.600	8.610	
## 120	mLN	61.400	4.100	21.400	15.500	1.460	33.800	0.990	17.000	16.400	
## 121	Spleen	29.600	4.970	15.700	6.010	6.720	48.900	1.510	25.300	7.570	
## 122	mLN	47.200	5.660	30.200	18.500	6.800	63.400	1.520	47.900	15.600	
## 123	mLN	48.200	12.400	17.900	7.520	3.990	52.900	2.200	36.600	26.100	
## 124	Spleen	12.300	14.600	16.900	4.650	6.650	37.400	3.290	20.400	11.600	
## 125	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 126	Spleen	27.300	6.370	19.500	4.390	8.860	53.900	1.100	25.800	6.360	
## 127	mLN	50.100	7.080	22.200	14.200	4.950	59.500	1.070	23.700	13.800	
## 128	Spleen	17.100	12.700	17.800	2.590	4.080	43.200	2.100	16.300	17.600	
## 129	mLN	41.900	11.900	22.200	5.660	4.860	55.800	1.260	26.500	27.900	
## 130	Spleen	13.300	13.400	18.000	6.200	6.450	47.000	4.140	27.000	11.100	
## 131	mLN	46.800	10.900	24.100	5.860	4.200	66.300	1.520	48.000	28.400	
## 132	mLN	41.600	12.900	23.000	6.090	3.800	56.500	2.160	35.900	25.200	
## 133	Spleen	13.400	15.600	16.700	3.910	5.050	45.100	3.720	16.600	14.100	
## 134	mLN	44.300	6.690	40.900	11.000	6.350	71.900	1.470	56.200	13.900	
## 135	Spleen	30.000	7.800	24.200	4.440	5.470	54.800	1.320	27.400	7.800	
## 136	Spleen	33.700	5.690	24.100	4.150	6.420	24.400	1.370	13.800	7.680	
## 137	mLN	32.600	3.810	43.200	13.500	4.170	53.800	4.810	11.100	14.400	
## 138	Spleen	33.000	5.640	20.500	7.420	7.390	54.900	1.170	31.400	8.200	
## 139	mLN	49.700	6.950	30.000	19.500	5.040	62.200	1.410	42.000	14.800	
## 140	mLN	43.400	5.480	24.900	13.100	5.660	62.700	1.320	36.100	14.500	
## 141	Spleen	34.400	5.730	21.500	3.360	3.550	51.300	0.880	14.500	8.220	
## 142	mLN	46.300	8.690	32.700	13.300	9.290	51.800	1.280	27.100	13.900	
## 143	Spleen	26.700	9.680	21.700	3.970	8.100	42.500	1.290	16.500	6.280	
## 144	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 145	Spleen	15.200	16.400	32.700	2.320	5.290	73.100	2.400	20.000	16.700	
## 146	mLN	31.600	12.300	26.100	4.030	6.460	81.700	1.230	46.300	23.800	
## 147	Spleen	17.500	12.900	15.800	2.960	6.210	23.300	1.720	20.500	16.700	
## 148	mLN	49.200	9.760	15.300	6.320	2.260	29.600	1.390	26.300	23.300	
## 149	Spleen	19.800	12.800	14.600	2.220	4.100	25.400	1.910	17.400	16.800	
## 150	mLN	53.400	10.400	14.300	4.680	1.580	43.200	1.520	37.100	24.500	
## 151	mLN	60.000	5.260	16.000	9.450	3.040	26.100	0.780	15.100	17.500	
## 152	Spleen	40.300	4.720	17.400	4.030	6.220	20.400	0.890	11.500	8.570	
## 153	Spleen	28.900	6.130	14.600	5.400	4.660	35.400	1.310	25.400	9.000	
## 154	mLN	47.600	5.920	24.300	13.400	5.750	46.100	1.120	31.900	19.100	
## 155	mLN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
## 156	Spleen	36.000	5.900	20.500	4.530	5.780	22.600	0.790	14.600	7.230	
## 157	mLN	50.600	5.740	18.500	7.520	2.020	20.700	1.310	15.300	11.700	
## 158	Spleen	32.600	5.930	14.600	4.570	4.560	30.100	0.970	20.100	7.800	

	mLN	53.000	5.560	21.900	12.800	4.380	41.900	1.410	25.800	15.000
## 159										
##	Act_CD8	Div_Act_CD8	IFNy_CD4	IFNy_CD8		OPG_0	IFNy_FEC	Caecum		
## 1	11.500	49.520	4.915	21.740	15567.7656	7.0252612	pos			
## 2	13.205	59.090	9.085	27.535	79646.0177	4.9987531	pos			
## 3	10.915	11.535	3.045	41.360	0.0000	1.6566446	neg			
## 4	11.105	55.935	9.085	38.165	53380.7829	0.8876691	pos			
## 5	9.815	12.830	2.005	19.390	0.0000	1.7767341	pos			
## 6	5.395	21.310	2.795	19.230	0.0000	4.8692310	neg			
## 7	8.900	55.690	8.455	34.310	41411.0429	5.9821940	pos			
## 8	9.200	55.970	8.755	28.690	5263.1579	2.1203409	pos			
## 9	8.375	45.895	12.910	46.265	33261.8026	0.9399154	pos			
## 10	18.260	38.450	4.590	27.800	157608.6957	3.4798154	pos			
## 11	3.785	8.985	1.690	13.755	0.0000	5.6873089	pos			
## 12	13.460	38.515	9.600	30.505	1798.5612	5.6173881	pos			
## 13	3.455	8.710	1.950	13.490	350.1401	5.7496557	pos			
## 14	7.815	60.255	8.380	29.545	4000.0000	4.4365197	pos			
## 15	4.930	44.240	4.355	23.725	2767.5277	1.6243585	pos			
## 16	4.755	15.410	1.810	11.825	0.0000	10.7285611	pos			
## 17	5.640	6.335	1.650	16.100	0.0000	6.3485357	neg			
## 18	20.500	29.365	3.240	27.110	65602.8369	7.0619458	pos			
## 19	4.455	12.675	2.580	22.560	0.0000	3.4229556	neg			
## 20	7.630	39.930	4.845	26.830	11986.3014	6.9702448	pos			
## 21	13.385	33.365	1.740	16.375	34836.0656	2.8337684	pos			
## 22	11.430	47.355	3.415	26.765	2906.9767	4.4546275	neg			
## 23	10.910	47.475	2.620	16.955	0.0000	NA	neg			
## 24	4.740	7.560	1.760	14.625	0.0000	0.0000000	neg			
## 25	19.175	31.745	3.055	19.105	1760.5634	NA	neg			
## 26	11.125	29.020	2.900	23.535	32051.2821	NA	pos			
## 27	6.615	10.910	1.110	20.565	0.0000	15.6812527	neg			
## 28	6.945	43.535	2.015	11.530	1020.4082	NA	neg			
## 29	2.365	6.815	1.130	8.335	0.0000	9.6548723	neg			
## 30	4.765	7.740	1.825	15.605	0.0000	4.7844621	neg			
## 31	16.415	45.830	5.475	31.365	0.0000	NA	pos			
## 32	7.845	51.610	5.170	21.410	0.0000	NA	neg			
## 33	3.855	10.130	1.360	8.335	0.0000	1.6566446	neg			
## 34	3.985	23.610	1.225	10.585	0.0000	NA	neg			
## 35	2.810	15.015	2.010	8.880	0.0000	NA	neg			
## 36	17.735	27.745	3.215	34.270	0.0000	NA	neg			
## 37	6.500	18.930	3.605	22.265	0.0000	NA	neg			
## 38	3.325	12.075	0.410	3.605	0.0000	NA	neg			
## 39	3.900	6.500	1.020	7.420	0.0000	NA	neg			
## 40	21.605	36.210	2.315	14.775	4545.4545	NA	neg			
## 41	8.135	46.220	2.310	17.460	0.0000	NA	pos			
## 42	6.720	17.135	2.780	18.350	0.0000	NA	neg			
## 43	4.220	16.695	0.830	9.825	0.0000	NA	neg			
## 44	7.410	46.670	1.325	4.500	1666.6667	NA	pos			
## 45	7.460	43.700	1.455	7.310	85714.2857	NA	pos			
## 46	8.910	6.915	0.400	5.010	0.0000	NA	neg			
## 47	15.035	35.205	1.540	9.265	1968.5039	NA	pos			
## 48	7.580	9.960	0.430	4.315	0.0000	NA	neg			
## 49	5.160	6.565	1.070	9.730	0.0000	NA	neg			
## 51	9.665	10.630	0.665	7.805	0.0000	NA	neg			
## 52	NA	NA	NA	NA	NA	NA	<NA>			
## 53	12.985	49.650	2.520	14.905	37500.0000	NA	pos			

## 54	NA	NA	NA	NA	NA	NA	<NA>
## 55	NA	NA	NA	NA	NA	NA	<NA>
## 56	NA	NA	NA	NA	NA	NA	<NA>
## 57	NA	NA	NA	NA	NA	NA	<NA>
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## 70	29.500	17.000	8.740	51.000	NA	NA	<NA>
## 71	11.400	24.400	5.820	38.300	NA	NA	<NA>
## 72	16.200	22.800	8.400	37.700	NA	NA	<NA>
## 73	27.000	17.300	15.600	34.900	NA	NA	<NA>
## 74	12.400	30.600	2.850	23.700	NA	NA	<NA>
## 75	27.300	23.700	13.500	41.600	NA	NA	<NA>
## 76	13.700	6.070	3.050	21.500	NA	NA	<NA>
## 77	25.200	4.350	12.900	31.000	NA	NA	<NA>
## 78	43.000	25.100	13.500	54.900	NA	NA	<NA>
## 79	19.500	26.500	9.340	36.900	NA	NA	<NA>
## 80	12.800	16.600	3.910	28.900	NA	NA	<NA>
## 81	31.600	16.700	9.280	38.100	NA	NA	<NA>
## 82	20.500	22.500	9.130	50.100	NA	NA	<NA>
## 83	54.100	21.400	28.200	67.100	NA	NA	<NA>
## 84	3.370	11.800	6.590	7.210	NA	NA	<NA>
## 85	13.400	7.650	15.600	18.200	NA	NA	<NA>
## 86	21.000	22.100	17.300	31.300	NA	NA	<NA>
## 87	10.200	23.500	9.700	21.500	NA	NA	<NA>
## 88	7.520	7.410	2.720	20.300	NA	NA	<NA>
## 89	15.700	10.200	10.200	28.500	NA	NA	<NA>
## 90	26.500	42.500	3.110	22.000	NA	NA	<NA>
## 91	15.400	37.600	9.080	20.200	NA	NA	<NA>
## 92	25.900	62.700	2.700	14.500	NA	NA	<NA>
## 93	22.200	26.400	10.300	22.000	NA	NA	<NA>
## 94	NA	NA	NA	NA	NA	NA	<NA>
## 95	22.900	7.810	5.550	34.200	NA	NA	<NA>
## 96	7.370	8.520	1.110	20.100	NA	NA	<NA>
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## 113     NA      NA      NA      NA      NA      NA <NA>
## 114     NA      NA      NA      NA      NA      NA <NA>
## 115     NA      NA      NA      NA      NA      NA <NA>
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## 117 12.500 20.300  5.360 38.100    NA      NA <NA>
## 118 14.400 29.100  2.870 23.500    NA      NA <NA>
## 119 10.700 13.000  3.670 17.600    NA      NA <NA>
## 120   4.370 11.600  0.340 16.200    NA      NA <NA>
## 121 11.900 37.600  6.430 32.100    NA      NA <NA>
## 122 11.200 38.900  2.840 18.200    NA      NA <NA>
## 123 14.000 38.100  1.670 21.100    NA      NA <NA>
## 124   8.290 40.300  5.150 17.600    NA      NA <NA>
## 125     NA      NA      NA      NA      NA      NA <NA>
## 126 17.500 44.700  6.430 32.200    NA      NA <NA>
## 127 11.200 43.000  2.240 35.600    NA      NA <NA>
## 128 10.400 40.700  3.110  4.030    NA      NA <NA>
## 129 13.300 54.100  1.850 12.200    NA      NA <NA>
## 130   5.070 40.400  8.720 13.200    NA      NA <NA>
## 131 13.900 41.800  2.600 23.500    NA      NA <NA>
## 132 10.700 44.300  2.050 15.100    NA      NA <NA>
## 133 17.300 24.100  3.470  7.440    NA      NA <NA>
## 134 20.900 52.200  2.920 31.400    NA      NA <NA>
## 135 11.700 43.500  3.940 24.700    NA      NA <NA>
## 136 15.400 14.600  5.660 33.100    NA      NA <NA>
## 137 12.100 28.800  1.960 25.100    NA      NA <NA>
## 138 16.600 39.800  5.000 26.600    NA      NA <NA>
## 139 10.900 41.400  1.060 10.300    NA      NA <NA>
## 140 18.600 40.200  1.890 16.700    NA      NA <NA>
## 141 13.500 40.900  3.390 22.600    NA      NA <NA>
## 142 19.400 32.900  6.730 28.300    NA      NA <NA>
## 143 13.600 30.000 11.300 47.800    NA      NA <NA>
## 144     NA      NA      NA      NA      NA      NA <NA>
## 145 14.200 28.300  4.770  3.420    NA      NA <NA>
## 146 20.900 48.600  2.360  8.070    NA      NA <NA>
## 147 11.300 20.100  4.750 14.200    NA      NA <NA>
## 148 14.100 15.500  1.540 18.200    NA      NA <NA>
## 149 11.700 18.700  3.410 14.900    NA      NA <NA>
## 150 13.400 16.200  1.320 16.900    NA      NA <NA>
## 151   8.380   7.740  1.700 14.500    NA      NA <NA>
## 152 15.700   8.560  4.290 23.000    NA      NA <NA>
## 153 12.600 25.800  5.430 38.400    NA      NA <NA>
## 154 11.500 27.000  3.970 32.000    NA      NA <NA>
## 155     NA      NA      NA      NA      NA      NA <NA>
## 156 14.200 14.100  3.880 19.300    NA      NA <NA>
## 157   7.110   7.550  0.750 24.400    NA      NA <NA>
## 158   9.610 24.600  5.460 32.600    NA      NA <NA>
## 159   7.470 33.400  2.130 22.100    NA      NA <NA>
## Treg_prop IL17A_CD4 batch max_dpi max_OOC  max_WL    death
## 1    93.605  0.415 <NA>       8 245000 95.89271 challenge
## 2    92.970  0.385 <NA>       8 875000 100.00000 challenge
## 3    92.845  0.575 <NA>       8      0 96.43232 challenge
## 4    93.505  0.850 <NA>       8 1257500 98.74335 challenge
## 5    91.305  0.250 <NA>       8      0 100.00000 challenge
## 6    93.110  0.270 <NA>       8      0 99.93282 challenge

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## 7	93.935	0.295	<NA>	8	1057500	97.89377	challenge
## 8	93.460	0.280	<NA>	8	377500	97.70174	challenge
## 9	93.535	0.610	<NA>	8	792500	88.95238	challenge
## 10	91.075	0.335	<NA>	8	437500	93.92239	challenge
## 11	96.360	0.385	<NA>	8	0	95.15714	challenge
## 12	90.935	0.640	<NA>	8	317500	100.00000	challenge
## 13	93.100	0.165	<NA>	8	12500	95.57685	challenge
## 14	93.865	1.025	<NA>	8	1272500	87.72379	challenge
## 15	93.510	0.730	<NA>	8	370000	91.07280	challenge
## 16	94.330	0.380	<NA>	8	0	94.30052	challenge
## 17	93.290	0.270	<NA>	8	0	94.26523	challenge
## 18	91.015	1.075	<NA>	8	317500	93.04491	challenge
## 19	94.870	0.480	<NA>	8	0	100.00000	challenge
## 20	94.905	0.420	<NA>	8	282500	89.84615	challenge
## 21	92.060	0.515	<NA>	8	605000	91.89463	challenge
## 22	92.795	0.500	<NA>	8	645000	98.02700	challenge
## 23	94.730	0.600	<NA>	8	290000	89.59338	challenge
## 24	90.950	0.250	<NA>	8	0	93.03136	challenge
## 25	72.660	0.460	<NA>	8	102500	98.95883	challenge
## 26	93.260	0.760	<NA>	8	322500	95.67059	challenge
## 27	90.525	0.395	<NA>	8	0	98.71365	challenge
## 28	94.700	1.225	<NA>	8	135000	89.78434	challenge
## 29	95.165	0.385	<NA>	8	0	81.82957	challenge
## 30	96.080	0.525	<NA>	8	0	90.45106	challenge
## 31	95.405	0.465	<NA>	8	47500	91.25000	challenge
## 32	93.705	1.410	<NA>	8	180000	94.18167	challenge
## 33	91.535	0.350	<NA>	8	2500	93.44330	challenge
## 34	92.525	0.620	<NA>	8	0	98.81423	challenge
## 35	94.675	0.460	<NA>	8	0	95.25346	challenge
## 36	88.400	0.860	<NA>	8	0	100.00000	challenge
## 37	94.400	1.315	<NA>	8	0	100.00000	challenge
## 38	95.245	0.385	<NA>	8	0	89.44724	challenge
## 39	94.960	0.475	<NA>	8	0	100.00000	challenge
## 40	85.590	2.340	<NA>	8	205000	95.59719	challenge
## 41	96.200	0.600	<NA>	8	242500	100.00000	challenge
## 42	95.235	0.710	<NA>	8	0	100.00000	challenge
## 43	90.600	0.745	<NA>	8	0	96.33508	challenge
## 44	92.955	0.850	<NA>	8	242500	97.72220	challenge
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## 46	92.620	0.430	<NA>	8	0	98.32197	challenge
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## 48	94.320	0.335	<NA>	8	0	96.20061	challenge
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## 58	NA	NA	<NA>	8	217500	83.74761	challenge
## 62	NA	NA	<NA>	8	5000	92.72388	challenge
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## 66	NA	NA	<NA>	8	-Inf	96.09053	challenge
## 67	NA	NA	<NA>	8	877500	89.18919	challenge
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## 129	NA	NA	b	8	1447500	77.80488	challenge
## 130	NA	NA	b	8	17500	89.00647	challenge
## 131	NA	NA	b	8	17500	89.00647	challenge
## 132	NA	NA	b	8	155000	83.27273	challenge
## 133	NA	NA	b	8	155000	83.27273	challenge
## 134	NA	NA	b	8	72500	78.11052	challenge
## 135	NA	NA	b	8	72500	78.11052	challenge
## 136	NA	NA	b	8	0	95.77811	challenge
## 137	NA	NA	b	8	0	95.77811	challenge
## 138	NA	NA	b	8	67500	82.87197	challenge
## 139	NA	NA	b	8	67500	82.87197	challenge
## 140	NA	NA	b	8	132500	75.33199	challenge
## 141	NA	NA	b	8	132500	75.33199	challenge
## 142	NA	NA	b	8	10000	90.31579	challenge
## 143	NA	NA	b	8	10000	90.31579	challenge
## 144	NA	NA	<NA>	8	0	80.74667	challenge
## 145	NA	NA	b	8	315000	73.44595	challenge
## 146	NA	NA	b	8	315000	73.44595	challenge
## 147	NA	NA	b	8	0	94.09011	challenge
## 148	NA	NA	b	8	0	94.09011	challenge
## 149	NA	NA	b	8	0	97.17833	challenge
## 150	NA	NA	b	8	0	97.17833	challenge
## 151	NA	NA	b	8	0	98.91892	challenge
## 152	NA	NA	b	8	0	98.91892	challenge
## 153	NA	NA	b	8	70000	87.36789	challenge
## 154	NA	NA	b	8	70000	87.36789	challenge
## 155	NA	NA	<NA>	8	0	80.47099	challenge
## 156	NA	NA	b	8	0	94.55754	challenge
## 157	NA	NA	b	8	0	94.55754	challenge
## 158	NA	NA	b	8	15000	88.39378	challenge
## 159	NA	NA	b	8	15000	88.39378	challenge
##	hybrid_status	Parasite_primary	Parasite_challenge	dpi_max	origin	Sex	
## 1	F1 hybrid	E_falciformis	E_ferrisi	8	Lab	<NA>	
## 2	F1 hybrid	E_falciformis	E_ferrisi	8	Lab	<NA>	
## 3	F0 M. m. domesticus	E_falciformis	uninfected	8	Lab	<NA>	
## 4	F1 hybrid	E_falciformis	E_ferrisi	8	Lab	<NA>	
## 5	F1 hybrid	E_falciformis	uninfected	8	Lab	<NA>	
## 6	F0 M. m. domesticus	E_falciformis	uninfected	8	Lab	<NA>	
## 7	F0 M. m. domesticus	E_falciformis	E_ferrisi	8	Lab	<NA>	
## 8	F1 M. m. domesticus	E_falciformis	E_ferrisi	8	Lab	<NA>	
## 9	F0 M. m. domesticus	E_falciformis	E_ferrisi	8	Lab	<NA>	
## 10	F1 M. m. musculus	E_falciformis	E_ferrisi	8	Lab	<NA>	
## 11	F0 M. m. domesticus	E_falciformis	uninfected	8	Lab	<NA>	
## 12	F1 hybrid	E_falciformis	E_ferrisi	8	Lab	<NA>	
## 13	F1 M. m. domesticus	E_falciformis	uninfected	8	Lab	<NA>	
## 14	F1 M. m. domesticus	E_falciformis	E_ferrisi	8	Lab	<NA>	

## 15	F1	M. m. domesticus	E_falciformis	E_ferrisi	8	Lab <NA>
## 16		F1 hybrid	E_falciformis	uninfected	8	Lab <NA>
## 17		F1 hybrid	E_falciformis	uninfected	8	Lab <NA>
## 18	FO	M. m. musculus	E_falciformis	E_ferrisi	8	Lab <NA>
## 19	FO	M. m. domesticus	E_falciformis	uninfected	8	Lab <NA>
## 20	FO	M. m. domesticus	E_falciformis	E_ferrisi	8	Lab <NA>
## 21		F1 M. m. musculus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 22		F1 hybrid	E_ferrisi	E_ferrisi	8	Lab <NA>
## 23	FO	M. m. domesticus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 24		F1 hybrid	E_ferrisi	uninfected	8	Lab <NA>
## 25	FO	M. m. musculus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 26		F1 hybrid	E_ferrisi	E_ferrisi	8	Lab <NA>
## 27	FO	M. m. musculus	E_ferrisi	uninfected	8	Lab <NA>
## 28		F1 hybrid	E_ferrisi	E_ferrisi	8	Lab <NA>
## 29	F1	M. m. domesticus	E_ferrisi	uninfected	8	Lab <NA>
## 30	FO	M. m. domesticus	E_ferrisi	uninfected	8	Lab <NA>
## 31	F1	M. m. domesticus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 32	F1	M. m. domesticus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 33		F1 hybrid	E_ferrisi	uninfected	8	Lab <NA>
## 34		F1 hybrid	E_ferrisi	uninfected	8	Lab <NA>
## 35	F1	M. m. domesticus	E_ferrisi	uninfected	8	Lab <NA>
## 36		F1 hybrid	E_ferrisi	uninfected	8	Lab <NA>
## 37	FO	M. m. domesticus	E_ferrisi	uninfected	8	Lab <NA>
## 38		F1 hybrid	E_ferrisi	uninfected	8	Lab <NA>
## 39		F1 hybrid	E_ferrisi	uninfected	8	Lab <NA>
## 40	FO	M. m. musculus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 41	FO	M. m. domesticus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 42	FO	M. m. domesticus	E_ferrisi	uninfected	8	Lab <NA>
## 43	FO	M. m. musculus	E_ferrisi	uninfected	8	Lab <NA>
## 44		F1 hybrid	E_ferrisi	E_ferrisi	8	Lab <NA>
## 45	FO	M. m. musculus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 46	F1	M. m. musculus	E_ferrisi	uninfected	8	Lab <NA>
## 47	F1	M. m. musculus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 48	F1	M. m. musculus	E_ferrisi	uninfected	8	Lab <NA>
## 49	FO	M. m. domesticus	E_ferrisi	uninfected	8	Lab <NA>
## 51	F1	M. m. musculus	E_ferrisi	uninfected	8	Lab <NA>
## 52	FO	M. m. musculus	E_ferrisi	uninfected	8	Lab <NA>
## 53	FO	M. m. musculus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 54		other	E_falciformis	E_falciformis	8	Lab <NA>
## 55		other	E_falciformis	E_ferrisi	8	Lab <NA>
## 56		other	E_falciformis	uninfected	8	Lab <NA>
## 57		other	E_falciformis	uninfected	8	Lab <NA>
## 58		other	E_falciformis	E_ferrisi	8	Lab <NA>
## 62		other	E_ferrisi	uninfected	8	Lab <NA>
## 64		other	E_ferrisi	E_ferrisi	8	Lab <NA>
## 65		other	E_ferrisi	uninfected	8	Lab <NA>
## 66		other	uninfected	E_falciformis	2	Lab <NA>
## 67		other	uninfected	E_ferrisi	8	Lab <NA>
## 68		other	uninfected	E_ferrisi	8	Lab <NA>
## 69		other	E_falciformis	E_falciformis	8	Lab <NA>
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## 74	other	E_ferrisi	E_ferrisi	8	Lab <NA>
## 75	other	E_ferrisi	E_ferrisi	8	Lab <NA>
## 76	other	E_ferrisi	uninfected	8	Lab <NA>
## 77	other	E_ferrisi	uninfected	8	Lab <NA>
## 78	other	E_falciformis	E_falciformis	8	Lab <NA>
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## 84	other	E_falciformis	uninfected	8	Lab <NA>
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## 88	other	E_falciformis	uninfected	8	Lab <NA>
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## 94	other	uninfected	E_ferrisi	5	Lab <NA>
## 95	other	uninfected	uninfected	8	Lab <NA>
## 96	other	uninfected	uninfected	8	Lab <NA>
## 97	F0 M. m. domesticus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 98	F0 M. m. domesticus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 99	F0 M. m. musculus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 100	F0 M. m. domesticus	E_ferrisi	E_falciformis	8	Lab <NA>
## 101	F0 M. m. domesticus	E_ferrisi	E_falciformis	8	Lab <NA>
## 102	F0 M. m. musculus	E_ferrisi	E_falciformis	8	Lab <NA>
## 103	F0 M. m. domesticus	E_ferrisi	uninfected	8	Lab <NA>
## 104	F0 M. m. domesticus	E_ferrisi	uninfected	8	Lab <NA>
## 105	F0 M. m. musculus	E_ferrisi	uninfected	8	Lab <NA>
## 106	F0 M. m. domesticus	E_falciformis	E_falciformis	8	Lab <NA>
## 107	F0 M. m. domesticus	E_falciformis	E_ferrisi	8	Lab <NA>
## 108	F0 M. m. domesticus	E_falciformis	uninfected	8	Lab <NA>
## 110	F0 M. m. domesticus	uninfected	uninfected	8	Lab <NA>
## 111	F0 M. m. musculus	uninfected	uninfected	8	Lab <NA>
## 112	F0 M. m. musculus	uninfected	uninfected	8	Lab <NA>
## 113	F0 M. m. domesticus	uninfected	E_ferrisi	8	Lab <NA>
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## 115	F0 M. m. domesticus	uninfected	E_falciformis	8	Lab <NA>
## 116	F0 M. m. musculus	uninfected	E_falciformis	8	Lab <NA>
## 117	F0 M. m. domesticus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 118	F0 M. m. domesticus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 119	F0 M. m. domesticus	uninfected	uninfected	8	Lab <NA>
## 120	F0 M. m. domesticus	uninfected	uninfected	8	Lab <NA>
## 121	F0 M. m. domesticus	uninfected	E_ferrisi	8	Lab <NA>
## 122	F0 M. m. domesticus	uninfected	E_ferrisi	8	Lab <NA>
## 123	F0 M. m. musculus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 124	F0 M. m. musculus	E_ferrisi	E_ferrisi	8	Lab <NA>
## 125	F0 M. m. domesticus	uninfected	E_falciformis	7	Lab <NA>
## 126	F0 M. m. domesticus	uninfected	E_ferrisi	8	Lab <NA>
## 127	F0 M. m. domesticus	uninfected	E_ferrisi	8	Lab <NA>
## 128	F0 M. m. musculus	E_ferrisi	E_falciformis	8	Lab <NA>

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Heligmosomoides_polygurus Heterakis_sp counter Date_count N_oocysts_sq1

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## 36	NA	NA	NA	<NA>	<NA>	NA
## 37	NA	NA	NA	<NA>	<NA>	NA
## 38	NA	NA	NA	<NA>	<NA>	NA
## 39	NA	NA	NA	<NA>	<NA>	NA
## 40	NA	NA	NA	<NA>	<NA>	NA

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## 157	NA	NA	NA	NA	<NA>	<NA>	NA
## 158	NA	NA	NA	NA	<NA>	<NA>	NA
## 159	NA	NA	NA	NA	<NA>	<NA>	NA
## Ct.Mus	Oocyst_Predict_Crypto	ILWE_Crypto_Ct	ILWE_DNA_Content_ng.microliter				
## 1	NA	NA	NA	NA			NA
## 2	NA	NA	NA	NA			NA
## 3	NA	NA	NA	NA			NA
## 4	NA	NA	NA	NA			NA
## 5	NA	NA	NA	NA			NA
## 6	NA	NA	NA	NA			NA
## 7	NA	NA	NA	NA			NA
## 8	NA	NA	NA	NA			NA
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## 10	NA	NA	NA	NA			NA
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## 12	NA	NA	NA	NA			NA
## 13	NA	NA	NA	NA			NA
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## 15	NA	NA	NA	NA			NA
## 16	NA	NA	NA	NA			NA
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## 18	NA	NA	NA	NA			NA
## 19	NA	NA	NA	NA			NA
## 20	NA	NA	NA	NA			NA
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## 22	NA	NA	NA	NA			NA
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## 24	NA	NA	NA	NA			NA
## 25	NA	NA	NA	NA			NA
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## 27	NA	NA	NA	NA			NA
## 28	NA	NA	NA	NA			NA
## 29	NA	NA	NA	NA			NA
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## 32	NA	NA	NA	NA			NA
## 33	NA	NA	NA	NA			NA
## 34	NA	NA	NA	NA			NA
## 35	NA	NA	NA	NA			NA
## 36	NA	NA	NA	NA			NA
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## 38	NA	NA	NA	NA			NA
## 39	NA	NA	NA	NA			NA
## 40	NA	NA	NA	NA			NA
## 41	NA	NA	NA	NA			NA
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## 43	NA	NA	NA	NA			NA
## 44	NA	NA	NA	NA			NA
## 45	NA	NA	NA	NA			NA
## 46	NA	NA	NA	NA			NA
## 47	NA	NA	NA	NA			NA
## 48	NA	NA	NA	NA			NA

## 49	NA	NA	NA	NA
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## 52	NA	NA	NA	NA
## 53	NA	NA	NA	NA
## 54	NA	NA	NA	NA
## 55	NA	NA	NA	NA
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## 86	NA	NA	NA	NA
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## 89	NA	NA	NA	NA
## 90	NA	NA	NA	NA
## 91	NA	NA	NA	NA
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## 101	NA	NA	NA	NA
## 102	NA	NA	NA	NA
## 103	NA	NA	NA	NA
## 104	NA	NA	NA	NA
## 105	NA	NA	NA	NA
## 106	NA	NA	NA	NA
## 107	NA	NA	NA	NA

	Ticks	Host	<i>Aspiculuris_sp</i>	<i>Syphacia_sp</i>	<i>Taenia_sp</i>	<i>Hymenolepis_sp</i>	Sperm
## 108	NA		NA		NA		NA
## 110	NA		NA		NA		NA
## 111	NA		NA		NA		NA
## 112	NA		NA		NA		NA
## 113	NA		NA		NA		NA
## 114	NA		NA		NA		NA
## 115	NA		NA		NA		NA
## 116	NA		NA		NA		NA
## 117	NA		NA		NA		NA
## 118	NA		NA		NA		NA
## 119	NA		NA		NA		NA
## 120	NA		NA		NA		NA
## 121	NA		NA		NA		NA
## 122	NA		NA		NA		NA
## 123	NA		NA		NA		NA
## 124	NA		NA		NA		NA
## 125	NA		NA		NA		NA
## 126	NA		NA		NA		NA
## 127	NA		NA		NA		NA
## 128	NA		NA		NA		NA
## 129	NA		NA		NA		NA
## 130	NA		NA		NA		NA
## 131	NA		NA		NA		NA
## 132	NA		NA		NA		NA
## 133	NA		NA		NA		NA
## 134	NA		NA		NA		NA
## 135	NA		NA		NA		NA
## 136	NA		NA		NA		NA
## 137	NA		NA		NA		NA
## 138	NA		NA		NA		NA
## 139	NA		NA		NA		NA
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## 155	NA		NA		NA		NA
## 156	NA		NA		NA		NA
## 157	NA		NA		NA		NA
## 158	NA		NA		NA		NA
## 159	NA		NA		NA		NA
##	Ticks	Host	<i>Aspiculuris_sp</i>	<i>Syphacia_sp</i>	<i>Taenia_sp</i>	<i>Hymenolepis_sp</i>	Sperm
## 1	NA <NA>		NA	NA	NA	NA	NA
## 2	NA <NA>		NA	NA	NA	NA	NA

## 3	NA <NA>	NA	NA	NA	NA	NA
## 4	NA <NA>	NA	NA	NA	NA	NA
## 5	NA <NA>	NA	NA	NA	NA	NA
## 6	NA <NA>	NA	NA	NA	NA	NA
## 7	NA <NA>	NA	NA	NA	NA	NA
## 8	NA <NA>	NA	NA	NA	NA	NA
## 9	NA <NA>	NA	NA	NA	NA	NA
## 10	NA <NA>	NA	NA	NA	NA	NA
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## 115	NA <NA>	NA	NA	NA	NA	NA
## 116	NA <NA>	NA	NA	NA	NA	NA

```

## 117 NA <NA> NA NA NA NA NA
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## 155 NA <NA> NA NA NA NA NA
## 156 NA <NA> NA NA NA NA NA
## 157 NA <NA> NA NA NA NA NA
## 158 NA <NA> NA NA NA NA NA
## 159 NA <NA> NA NA NA NA NA
## FEC_Eim_Ct MC.Eimeria.FEC MCs
## 1 NA NA <NA>
## 2 NA NA <NA>
## 3 NA NA <NA>
## 4 NA NA <NA>
## 5 NA NA <NA>
## 6 NA NA <NA>
## 7 NA NA <NA>
## 8 NA NA <NA>
## 9 NA NA <NA>
## 10 NA NA <NA>

```

```
## 11      NA      NA <NA>
## 12      NA      NA <NA>
## 13      NA      NA <NA>
## 14      NA      NA <NA>
## 15      NA      NA <NA>
## 16      NA      NA <NA>
## 17      NA      NA <NA>
## 18      NA      NA <NA>
## 19      NA      NA <NA>
## 20      NA      NA <NA>
## 21      NA      NA <NA>
## 22      NA      NA <NA>
## 23      NA      NA <NA>
## 24      NA      NA <NA>
## 25      NA      NA <NA>
## 26      NA      NA <NA>
## 27      NA      NA <NA>
## 28      NA      NA <NA>
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## 30      NA      NA <NA>
## 31      NA      NA <NA>
## 32      NA      NA <NA>
## 33      NA      NA <NA>
## 34      NA      NA <NA>
## 35      NA      NA <NA>
## 36      NA      NA <NA>
## 37      NA      NA <NA>
## 38      NA      NA <NA>
## 39      NA      NA <NA>
## 40      NA      NA <NA>
## 41      NA      NA <NA>
## 42      NA      NA <NA>
## 43      NA      NA <NA>
## 44      NA      NA <NA>
## 45      NA      NA <NA>
## 46      NA      NA <NA>
## 47      NA      NA <NA>
## 48      NA      NA <NA>
## 49      NA      NA <NA>
## 51      NA      NA <NA>
## 52      NA      NA <NA>
## 53      NA      NA <NA>
## 54      NA      NA <NA>
## 55      NA      NA <NA>
## 56      NA      NA <NA>
## 57      NA      NA <NA>
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## 62      NA      NA <NA>
## 64      NA      NA <NA>
## 65      NA      NA <NA>
## 66      NA      NA <NA>
## 67      NA      NA <NA>
## 68      NA      NA <NA>
## 69      NA      NA <NA>
```

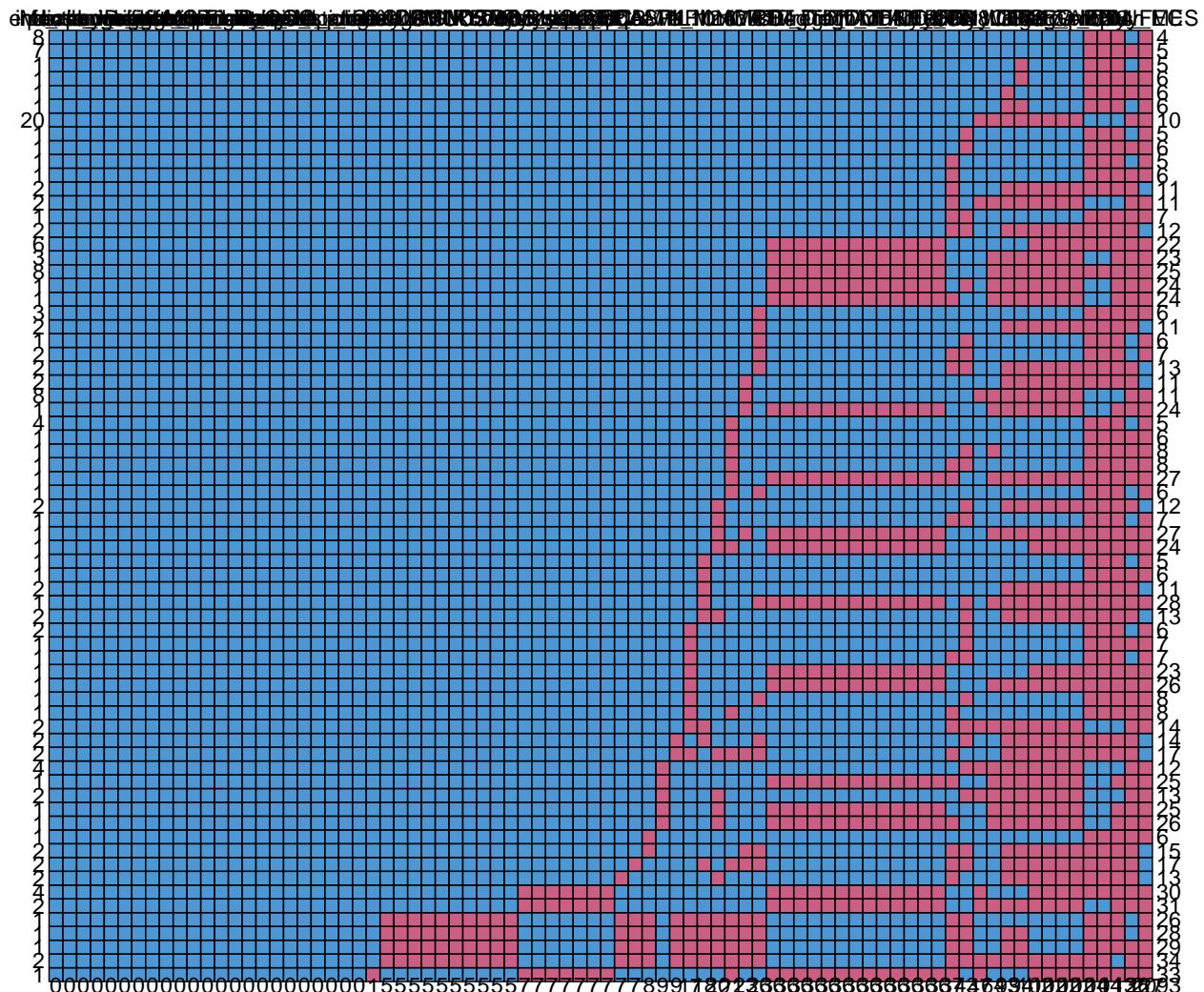
```
## 70      NA      NA <NA>
## 71      NA      NA <NA>
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## 120     NA      NA <NA>
## 121     NA      NA <NA>
## 122     NA      NA <NA>
## 123     NA      NA <NA>
## 124     NA      NA <NA>
```

```

## 125      NA      NA <NA>
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## 138      NA      NA <NA>
## 139      NA      NA <NA>
## 140      NA      NA <NA>
## 141      NA      NA <NA>
## 142      NA      NA <NA>
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## 155      NA      NA <NA>
## 156      NA      NA <NA>
## 157      NA      NA <NA>
## 158      NA      NA <NA>
## 159      NA      NA <NA>

# really removing empty columns
lab <- lab %>%
  discard(~all(is.na(.) | . == ""))
# looking at patterns of nas
pattern_na <- as.data.frame(md.pattern(lab))

```



```
#select the relevant columns to use for the imputation
lab_sel <- lab %>%
  dplyr::select(c(Mouse_ID, experiment, primary_infection, challenge_infection,
    mouse_strain, weight, weight_dpi0, relative_weight,
    oocyst_sq1, oocyst_sq2, oocyst_sq3, oocyst_sq4, O04sq, OOC,
    MC.Eimeria, delta_ct_cewe_MminusE, IFNy_CEWE, IFNy_MES,
    all_of(c(Facs_lab, Facs_wild, Gene_lab, Genes_wild))))
```

*# The frequency distribution of the missing cases per variable can be obtained
as:*

```
init <- mice(lab_sel, maxit = 0)
```

Warning: Number of logged events: 2

#we want to impute only the specific variables

```
meth <- init$method
```

#select all the colnames ending in std (the standardized ones)

```
#std <- colnames(lab %>% dplyr::select(ends_with("_std")))
```

set every variable that is not one of your variables of interest to ""

```

# You can supply a vector to the method argument of mice::mice. This vector should contain the methods to
# meth[!(names(meth) %in% all_of(std))] <- ""

# repeat the imputation only for the specific variables
# init <- mice(lab, maxit = 0, method = meth)

# table of amount of variables with the amount of missing values
# table(init$nmis)

# which method is used for imputation? In this case the package mice
# uses the default method for continuous variable,
# which is pmm, or predictive mean matching

# now impute the data and save it as the object:
# ifg

#vis_miss(lab)

#sapply(lab, function(x) sum(is.na(x)))

# will have to remove treg_prop and ooc, as they cause problems with the further
# imputation
lab_sel <- lab_sel %>%
  dplyr::select(-c(OOC, Treg_prop))

# which column numbers end in Std
#grep("_std", colnames(lab) )

#imp <- mice(lab, print = FALSE)

# m=5 refers to the number of imputed datasets. Five is the default value.
ifg <- mice(lab_sel[, -1], m = 5, seed = 500) # method = meth,
## iter imp variable
## 1 1 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFF
## 1 2 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE* IFF
## 1 3 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFF
## 1 4 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE* IFF
## 1 5 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE* IFF
## 2 1 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE* IFF
## 2 2 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFF
## 2 3 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFF
## 2 4 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFF
## 2 5 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFF
## 3 1 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFF
## 3 2 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFF
## 3 3 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFF
## 3 4 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFF
## 3 5 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFF
## 4 1 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE* IFF
## 4 2 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE* IFF
## 4 3 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE* IFF

```

```

## 4 4 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE* IFNy_CEWE*
## 4 5 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE* IFNy_CEWE*
## 5 1 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFNy_CEWE*
## 5 2 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE* IFNy_CEWE*
## 5 3 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFNy_CEWE*
## 5 4 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFNy_CEWE*
## 5 5 oocyst_sq1 oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq delta_ct_cewe_MminusE IFNy_CEWE IFNy_CEWE*

## Warning: Number of logged events: 1345
summary(igf)

## Class: mids
## Number of multiple imputations: 5
## Imputation methods:
##          experiment      primary_infection challenge_infection
##          ""              ""                  ""
##          mouse_strain    weight            weight_dpi0
##          ""              ""                  ""
##          relative_weight oocyst_sq1       oocyst_sq2
##          ""              "pmm"             "pmm"
##          oocyst_sq3       oocyst_sq4       004sq
##          "pmm"           "pmm"             "pmm"
##          MC.Eimeria     delta_ct_cewe_MminusE IFNy_CEWE
##          ""              "pmm"             "pmm"
##          IFNy_MES        CD4                Treg
##          "pmm"           "pmm"             "pmm"
##          Div_Treg        Treg17            Th1
##          "pmm"           "pmm"             "pmm"
##          Div_Th1         Th17               Div_Th17
##          "pmm"           "pmm"             "pmm"
##          CD8              Act_CD8            Div_Act_CD8
##          "pmm"           "pmm"             "pmm"
##          IFNy_CD4        IFNy_CD8          IL17A_CD4
##          "pmm"           "pmm"             "pmm"
##          IFNy             CXCR3             IL.6
##          "pmm"           "pmm"             "pmm"
##          IL.13            IL.10              IL1RN
##          "pmm"           "pmm"             "pmm"
##          CASP1            CXCL9             IDO1
##          "pmm"           "pmm"             "pmm"
##          IRGM1            MPO                MUC2
##          "pmm"           "pmm"             "pmm"
##          MUC5AC           MYD88             NCR1
##          "pmm"           "pmm"             "pmm"
##          PRF1              RETNLB            SOCS1
##          "pmm"           "pmm"             "pmm"
##          TICAM1            TNF
##          "pmm"           "pmm"

## PredictorMatrix:
##          experiment primary_infection challenge_infection
##          experiment          0              1              1
##          primary_infection     1              0              1
##          challenge_infection   1              1              0
##          mouse_strain          1              1              1

```

```

## weight          1          1          1
## weight_dpi0    1          1          1
##           mouse_strain weight weight_dpi0 relative_weight oocyst_sq1
## experiment      1          1          1          1          1
## primary_infection 1          1          1          1          1
## challenge_infection 1          1          1          1          1
## mouse_strain     0          1          1          1          1
## weight          1          0          1          1          1
## weight_dpi0     1          1          0          1          1
##           oocyst_sq2 oocyst_sq3 oocyst_sq4 004sq MC.Eimeria
## experiment      1          1          1          1          1
## primary_infection 1          1          1          1          1
## challenge_infection 1          1          1          1          1
## mouse_strain     1          1          1          1          1
## weight          1          1          1          1          1
## weight_dpi0     1          1          1          1          1
##           delta_ct_cewe_MminusE IFNy_CEWE IFNy_MES CD4 Treg Div_Treg
## experiment      1          1          1          1          1          1
## primary_infection 1          1          1          1          1          1
## challenge_infection 1          1          1          1          1          1
## mouse_strain     1          1          1          1          1          1
## weight          1          1          1          1          1          1
## weight_dpi0     1          1          1          1          1          1
##           Treg17 Th1 Div_Th1 Th17 Div_Th17 CD8 Act_CD8 Div_Act_CD8
## experiment      1          1          1          1          1          1          1
## primary_infection 1          1          1          1          1          1          1
## challenge_infection 1          1          1          1          1          1          1
## mouse_strain     1          1          1          1          1          1          1
## weight          1          1          1          1          1          1          1
## weight_dpi0     1          1          1          1          1          1          1
##           IFNy_CD4 IFNy_CD8 IL17A_CD4 IFNy CXCR3 IL.6 IL.13 IL.10
## experiment      1          1          1          1          1          1          1          1
## primary_infection 1          1          1          1          1          1          1          1
## challenge_infection 1          1          1          1          1          1          1          1
## mouse_strain     1          1          1          1          1          1          1          1
## weight          1          1          1          1          1          1          1          1
## weight_dpi0     1          1          1          1          1          1          1          1
##           IL1RN CASP1 CXCL9 IDO1 IRGM1 MPO MUC2 MUC5AC MYD88 NCR1
## experiment      1          1          1          1          1          1          1          1          1
## primary_infection 1          1          1          1          1          1          1          1          1
## challenge_infection 1          1          1          1          1          1          1          1          1
## mouse_strain     1          1          1          1          1          1          1          1          1
## weight          1          1          1          1          1          1          1          1          1
## weight_dpi0     1          1          1          1          1          1          1          1          1
##           PRF1 RETNLB SOCS1 TICAM1 TNF
## experiment      1          1          1          1          1
## primary_infection 1          1          1          1          1
## challenge_infection 1          1          1          1          1
## mouse_strain     1          1          1          1          1
## weight          1          1          1          1          1
## weight_dpi0     1          1          1          1          1
## Number of logged events: 1345
##   it im          dep meth
## 1 1 1       oocyst_sq1 pmm

```

```

## 2 1 1          oocyst_sq2 pmm
## 3 1 1          oocyst_sq3 pmm
## 4 1 1          oocyst_sq4 pmm
## 5 1 1          004sq  pmm
## 6 1 1 delta_ct_cewe_MminusE pmm
##
##                                     out
## 1                         mouse_strainNMRI, oocyst_sq4, 004sq
## 2                         mouse_strainNMRI, 004sq
## 3                         mouse_strainNMRI, 004sq
## 4                         mouse_strainNMRI, oocyst_sq1, 004sq
## 5 mouse_strainNMRI, oocyst_sq1, oocyst_sq2, oocyst_sq3, oocyst_sq4
## 6                         mouse_strainNMRI, weight_dpi0

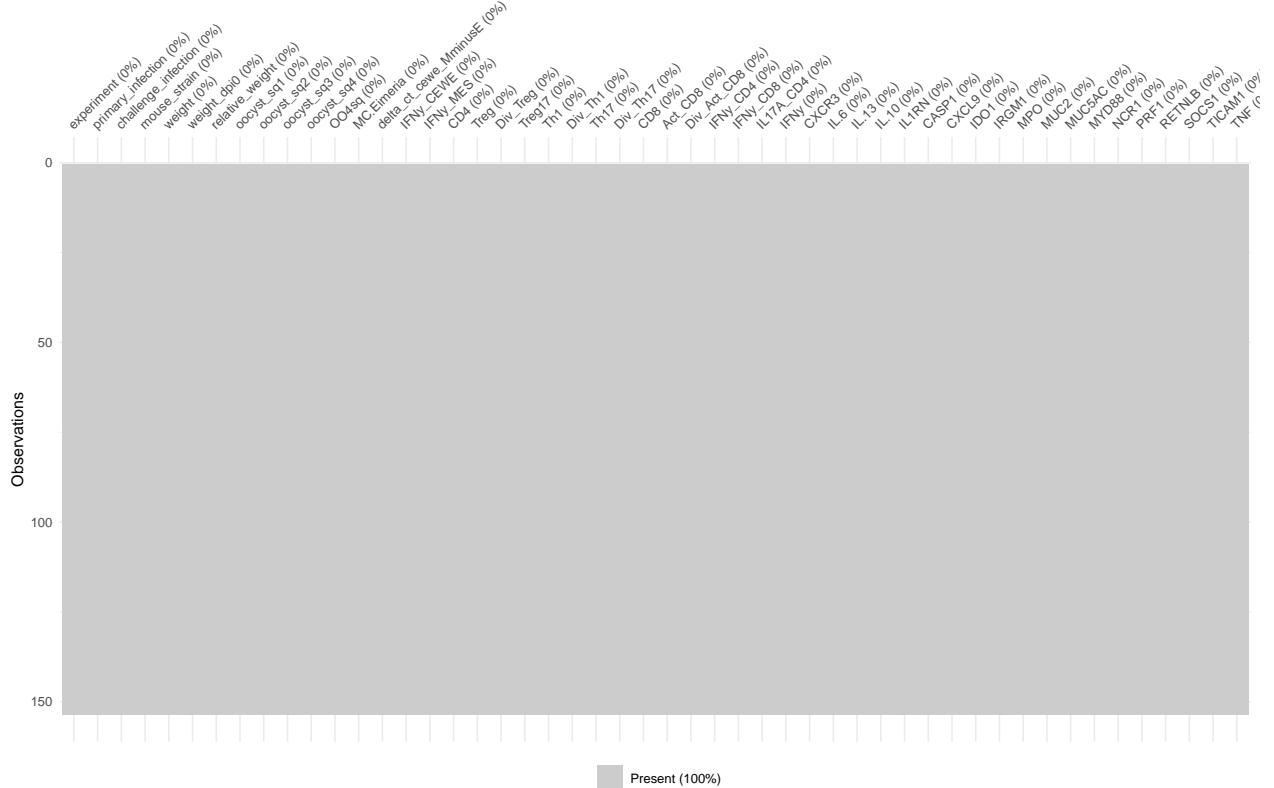
# to check each column with imputed data
## igf$imp$IFNy

#Now we can get back the completed dataset using the complete()
complete_lab <- complete(igf, 1)

#visualize missingness
vis_miss(complete_lab)

```

Warning: `gather_()` was deprecated in tidyverse 1.2.0.
Please use `gather()` instead.



```

#sapply(complete_lab, function(x) sum(is.na(x)))

imp_lab <- complete_lab %>%
  dplyr::select("CD4", "Treg", "Div_Treg", "Treg17", "Th1",
    "Div_Th1", "Th17", "Div_Th17", "CD8", "Act_CD8",

```

```

"Div_Act_CD8", "IFNy_CD4", "IFNy_CD8",
"IL17A_CD4", all_of(Gene_lab))

#add an ending to the imputed columns
colnames(imp_lab) <- paste(colnames(imp_lab), "imp", sep = "_")

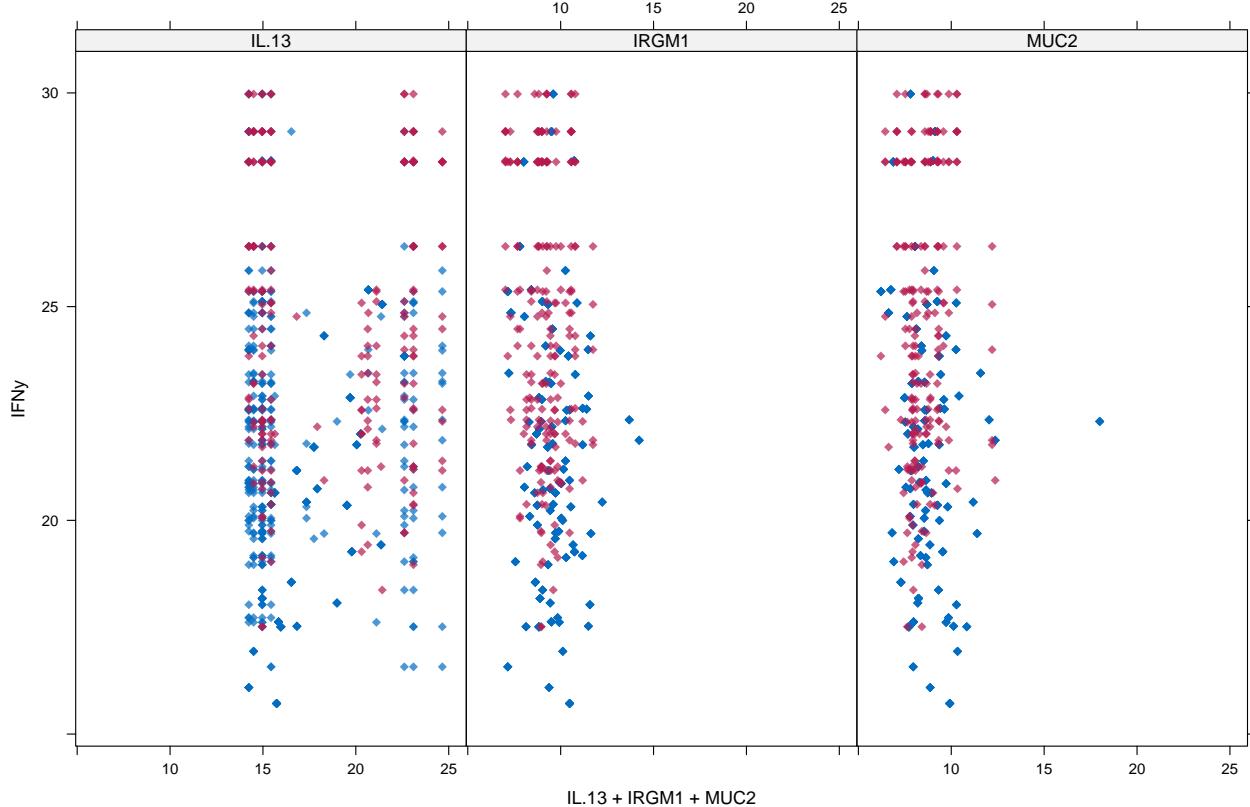
#now join it to the full data set of the laboratory infections
lab <- cbind(lab, imp_lab)

```

Predictive mean matching with $d = 5$ is the default in mice() for continuous data. The method is robust against misspecification of the imputation model, yet performs as well as theoretically superior methods. In the context of missing covariate data, Marshall, Altman, and Holder (2010) concluded that predictive mean matching “produced the least biased estimates and better model performance measures.” Another simulation study that addressed skewed data concluded that predictive mean matching “may be the preferred approach provided that less than 50% of the cases have missing data and the missing data are not MNAR” (Marshall et al. 2010). Kleinke (2017) found that the method works well across a wide variety of scenarios, but warned the default cannot address severe skewness or small samples.

Let’s compare the distributions of original and imputed data using a some useful plots. First of all we can use a scatterplot and plot Ozone against all the other variables. Let’s first plot the variables for which we have few missing values.

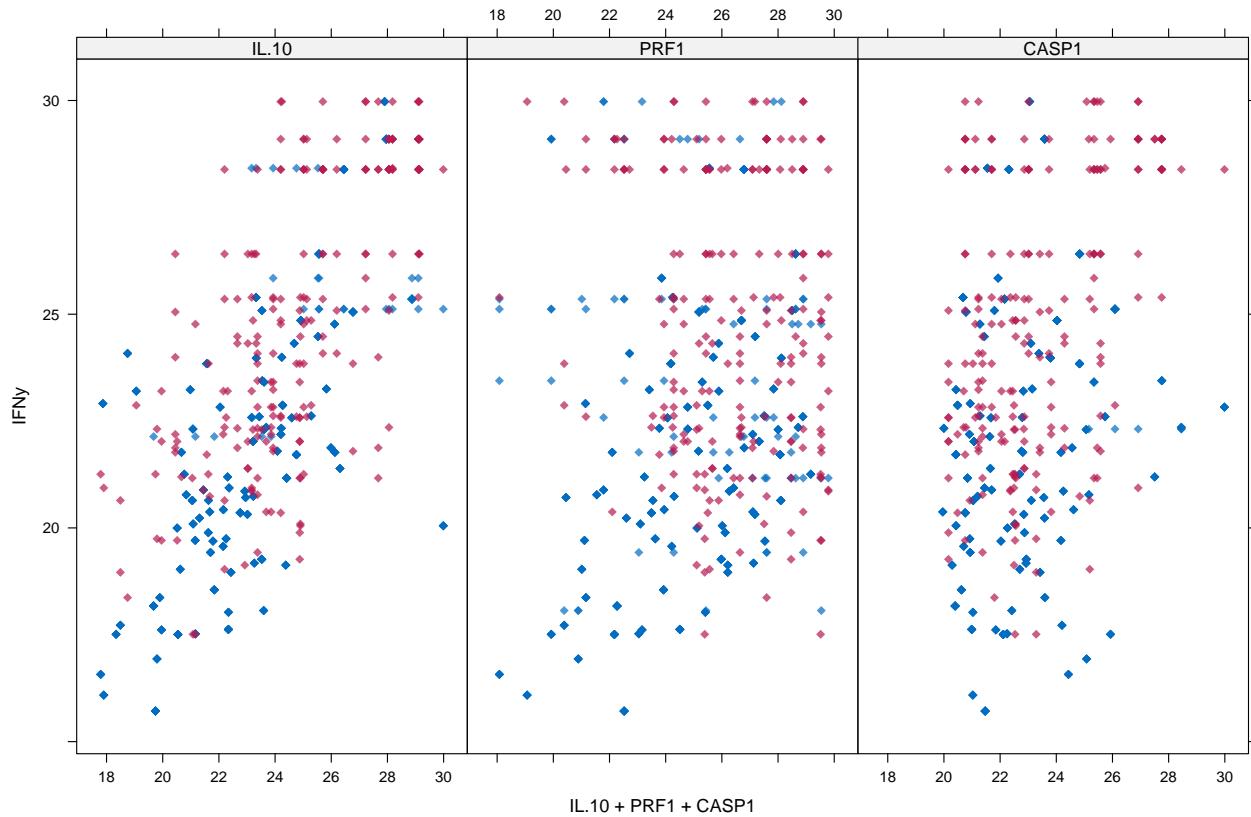
```
xyplot(igf, IFNy ~ IL.13 + IRGM1 + MUC2, pch=18, cex=1)
```



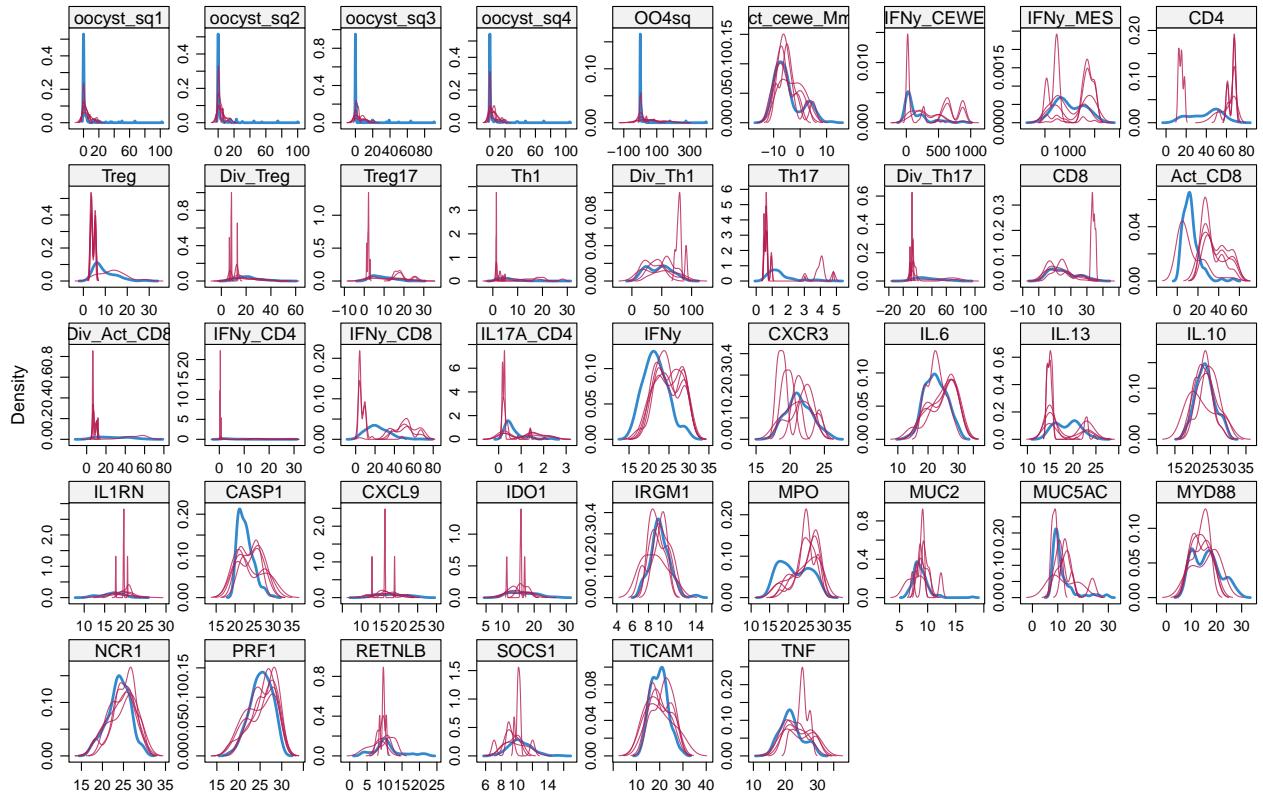
What we would like to see is that the shape of the magenta points (imputed) matches the shape of the blue ones (observed). The matching shape tells us that the imputed values are indeed “plausible values”.

Now let’s plot the variables with many missing data points.

```
xyplot(igf,IFNy ~ IL.10 + PRF1 + CASP1, pch=18,cex=1)
```



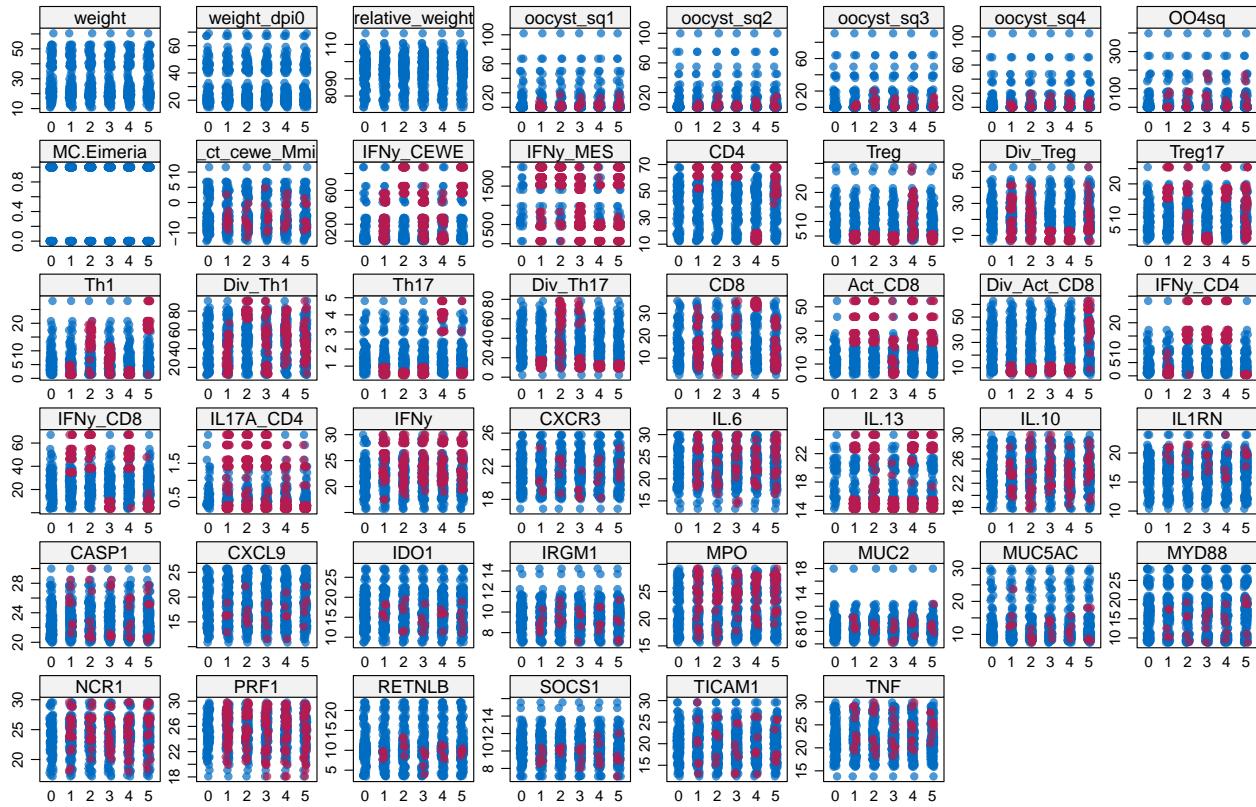
```
densityplot(igf)
```



The density of the imputed data for each imputed dataset is showed in magenta while the density of the observed data is showed in blue. Again, under our previous assumptions we expect the distributions to be similar.

Another useful visual take on the distributions can be obtained using the `stripplot()` function that shows the distributions of the variables as individual points

```
stripplot(igf, pch = 20, cex = 1.2)
```



field

Field data imputation

```

# field samples
field <- hm %>%
  filter(origin == "Field")

gf_field <- field %>%
  dplyr::select(all_of(c(Facs_lab, Facs_wild, Gene_lab, Genes_wild)))

#remove rows with only nas
gf_field <- gf_field[, colSums(is.na(gf_field)) < nrow(gf_field)] 

#remove columns with only nas
gf_field <- gf_field[rowSums(is.na(gf_field)) != ncol(gf_field), ] 

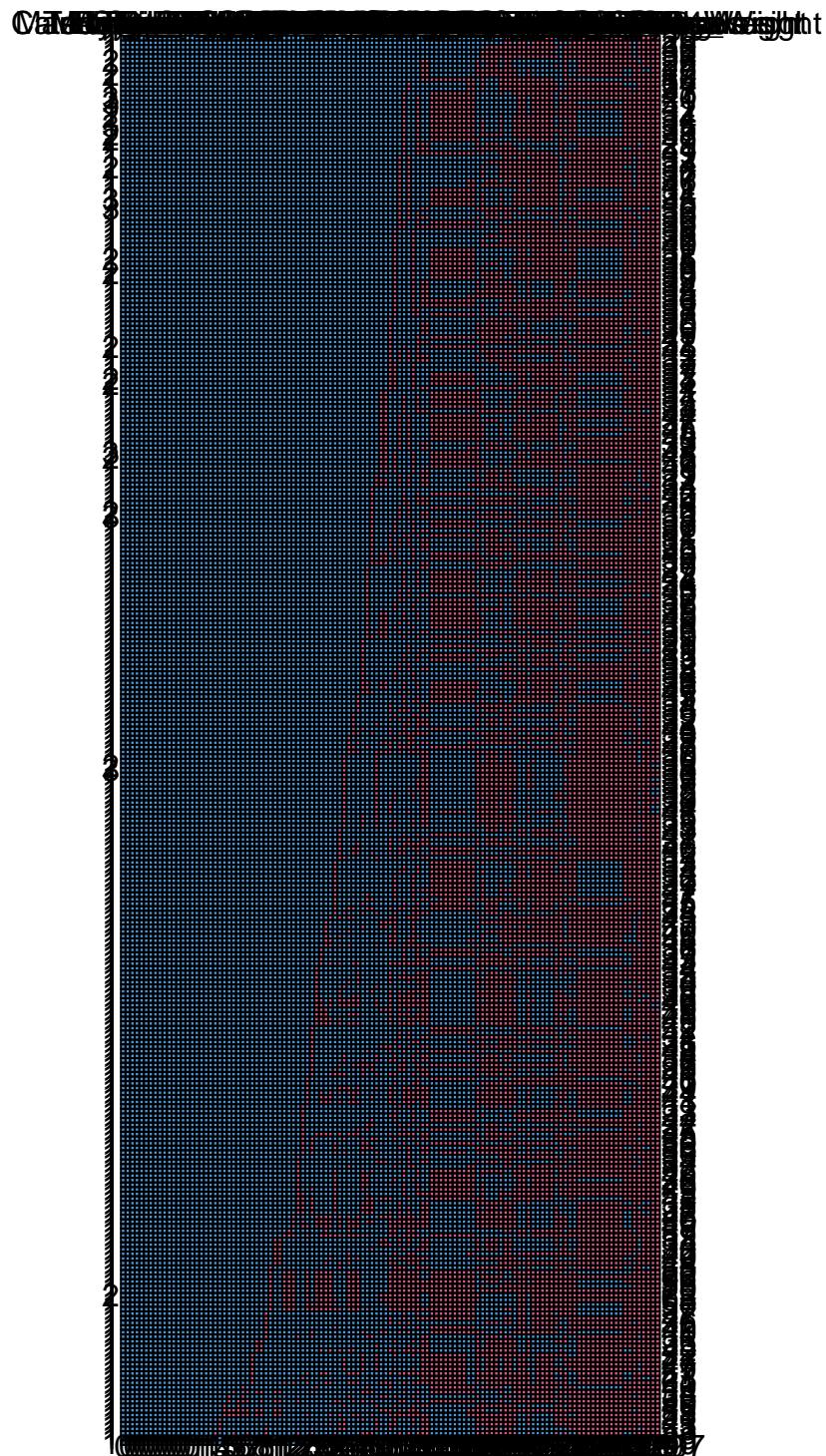
#select same rows in the first table
field <- field[row.names(gf_field), ] 

#remove wrongly normalized genes
field <- field %>%
  dplyr::select(-ends_with("_N"))

```

```
# really removing empty columns
field <- field %>%
  discard(~all(is.na(.) | . == ""))
  
# make a second data frame to keep this data frame at this point
f1 <- field

# looking at patterns of nans
pattern_na <- as.data.frame(md.pattern(field))
```



```
#sapply(field, function(x) sum(is.na(x)))  
  
#select the relevant columns to use for the imputation  
field <- field %>%  
  dplyr::select(c(Mouse_ID, MC.Eimeria, delta_ct_cewe_MminusE, Sex, Longitude, Latitude,  
    Year, mtBamH, YNPAR, X332, X347, X65, Tsx, Btk, Syap1, Es1,  
    Gpd1, Idh1, Mpi, Np, Sod1, Es1C, Gpd1C, Idh1C, NpC, Sod1C,  
    HI_NLoci, Spleen, Trichuris_muris, Mastophorus_muris,
```

```

Catenotaenia_pusilla, Status,
Heterakis_sp, N_oocysts_sq1,
N_oocysts_sq2, N_oocysts_sq3, N_oocysts_sq4, N_oocysts_sq5,
N_oocysts_sq6, N_oocysts_sq7, N_oocysts_sq8, Region,
Body_Length, Fleas, Tail_Length, eimeriaSpecies, Ct.Eimeria,
Ct.Mus, ILWE_Crypto_Ct, Aspicularis_sp, Syphacia_sp, Taenia_sp,
Hymenolepis_sp, FEC_Eim_Ct,
all_of(c(Facs_wild, Genes_wild)))
#had to remove as they were disturbing the imputation: Worms_presence, MC.Eimeria.FEC, Heligmosomoides

#vis_miss(field)

# The frequency distribution of the missing cases per variable can be obtained
# as:
init <- mice(field, maxit = 0)

#we want to impute only the specific variables
meth <- init$method

#select all the colnames ending in std (the standardized ones)
#std <- colnames(field %>% dplyr::select(ends_with("_std")))

# set every variable that is not one of your variables of interest to ""
#You can supply a vector to the method argument of mice::mice. This vector should contain the methods to
#meth[!(names(meth) %in% all_of(std))] <- ""

# repeat the imputation only for the specific variables
#init <- mice(field, maxit = 0, method = meth)

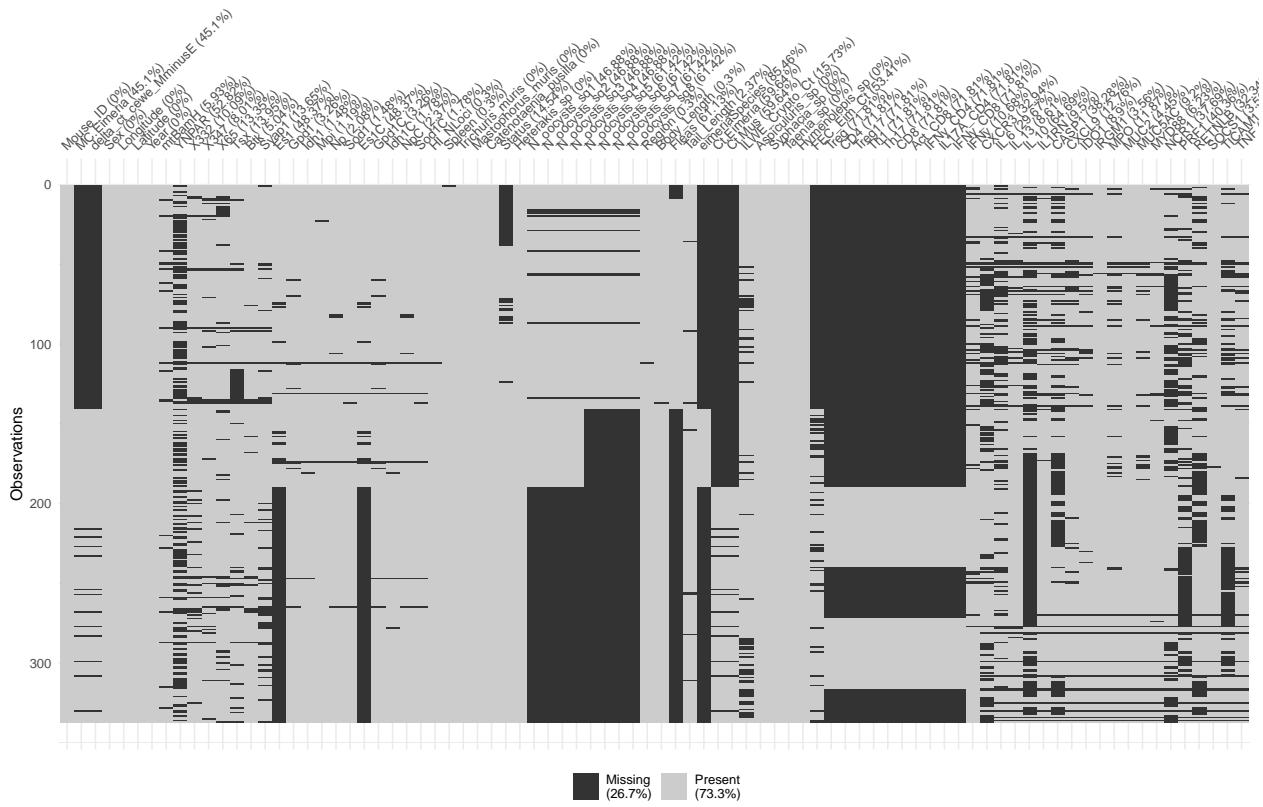
# table of amount of variables with the amount of missing values
#table(init$nmis)

# which method is used for imputation? In this case the package mice
# uses the default method for continuous variable,
# which is pmm, or predictive mean matching

# now impute the data and save it as the object:
# igf

vis_miss(field)

```



```

#sapply(field, function(x) sum(is.na(x)))

# will have to remove treg_prop and ooc, as they cause problems with the further
# imputation
#field <- field %>%
# # dplyr::select(-c(OOC, IFNy_MES, Treg_prop))

# which column numbers end in Std
#grep("_std", colnames(field) )

#imp <- mice(field, print = FALSE)

# m=5 refers to the number of imputed datasets. Five is the default value.
igf <- mice(field[, -1], m = 5, seed = 500) # method = meth,
## iter imp variable
## 1 1 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T
## 1 2 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T
## 1 3 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T
## 1 4 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T
## 1 5 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T
## 2 1 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T
## 2 2 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T
## 2 3 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T
## 2 4 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T
## 2 5 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T
## 3 1 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T
## 3 2 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 T

```

```

## 3 3 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 3 4 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 3 5 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 4 1 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 4 2 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 4 3 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 4 4 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 4 5 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 5 1 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 5 2 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 5 3 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 5 4 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G
## 5 5 MC.Eimeria delta_ct_cewe_MminusE* mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 G

## Warning: Number of logged events: 3065
summary(igf)

## Class: mids
## Number of multiple imputations: 5
## Imputation methods:
##          MC.Eimeria delta_ct_cewe_MminusE           Sex
##          "logreg"                  "pmm"           ""
##          Longitude                Latitude        Year
##          ""                      ""              ""
##          mtBamH                  YNPAR          X332
##          "polyreg"                "polyreg"      "polyreg"
##          X347                     X65            Tsx
##          "polyreg"                "polyreg"      "polyreg"
##          Btk                      Syap1          Es1
##          "polyreg"                "polyreg"      "polyreg"
##          Gpd1                     Idh1            Mpi
##          "polyreg"                "polyreg"      "polyreg"
##          Np                       Sod1            Es1C
##          "polyreg"                "polyreg"      "polyreg"
##          Gpd1C                   Idh1C           NpC
##          "polyreg"                "polyreg"      "polyreg"
##          Sod1C                   HI_NLoci       Spleen
##          "polyreg"                "pmm"           "pmm"
##          Trichuris_muris        Mastophorus_muris Catenotaenia_pusilla
##          ""                      ""              ""
##          Status                  Heterakis_sp    N_oocysts_sq1
##          "polyreg"                ""              "pmm"
##          N_oocysts_sq2          N_oocysts_sq3  N_oocysts_sq4
##          "pmm"                   "pmm"          "pmm"
##          N_oocysts_sq5          N_oocysts_sq6  N_oocysts_sq7
##          "pmm"                   "pmm"          "pmm"
##          N_oocysts_sq8          Region         Body_Length
##          "pmm"                   "polyreg"     "pmm"
##          Fleas                   Tail_Length   eimeriaSpecies
##          "logreg"                "pmm"          "polyreg"
##          Ct.Eimeria              Ct.Mus        ILWE_Crypto_Ct
##          "pmm"                   "pmm"          "pmm"
##          Aspiculuris_sp         Syphacia_sp   Taenia_sp
##          ""                      ""              ""

```

```

##      Hymenolepis_sp          FEC_Eim_Ct          Treg
##      ""                      "pmm"           "pmm"
##      CD4                     Treg17          Th1
##      "pmm"                   "pmm"           "pmm"
##      Th17                    CD8            Act_CD8
##      "pmm"                   "pmm"           "pmm"
##      IFNy_CD4                IL17A_CD4       IFNy_CD8
##      "pmm"                   "pmm"           "pmm"
##      IFNy                    CXCR3           IL.6
##      "pmm"                   "pmm"           "pmm"
##      IL.13                   IL.10           IL1RN
##      "pmm"                   "pmm"           "pmm"
##      CASP1                   CXCL9           IDO1
##      "pmm"                   "pmm"           "pmm"
##      IRGM1                   MPO            MUC2
##      "pmm"                   "pmm"           "pmm"
##      MUC5AC                  MYD88           NCR1
##      "pmm"                   "pmm"           "pmm"
##      PRF1                    RETNLB          SOCS1
##      "pmm"                   "pmm"           "pmm"
##      TICAM1                  TNF
##      "pmm"                   "pmm"

## PredictorMatrix:
##              MC.Eimeria delta_ct_cewe_MminusE Sex Longitude Latitude
## MC.Eimeria          0                      1   1          1   1
## delta_ct_cewe_MminusE 1                      0   1          1   1
## Sex                 1                      1   0          1   1
## Longitude           1                      1   1          0   1
## Latitude            1                      1   1          1   0
## Year                1                      1   1          1   1
##              Year mtBamH YNPAR X332 X347 X65 Tsx Btk Syap1 Es1 Gpd1
## MC.Eimeria          1     1     1     1     1     1     1     1     1     1     1
## delta_ct_cewe_MminusE 1     1     1     1     1     1     1     1     1     1     1
## Sex                 1     1     1     1     1     1     1     1     1     1     1
## Longitude           1     1     1     1     1     1     1     1     1     1     1
## Latitude            1     1     1     1     1     1     1     1     1     1     1
## Year                0     1     1     1     1     1     1     1     1     1     1
##              Idh1 Mpi Np Sod1 Es1C Gpd1C Idh1C NpC Sod1C HI_NLoci
## MC.Eimeria          1     1     1     1     1     1     1     1     1     1
## delta_ct_cewe_MminusE 1     1     1     1     1     1     1     1     1     1
## Sex                 1     1     1     1     1     1     1     1     1     1
## Longitude           1     1     1     1     1     1     1     1     1     1
## Latitude            1     1     1     1     1     1     1     1     1     1
## Year                1     1     1     1     1     1     1     1     1     1
##              Spleen Trichuris_muris Mastophorus_muris
## MC.Eimeria          1             1             1
## delta_ct_cewe_MminusE 1             1             1
## Sex                 1             1             1
## Longitude           1             1             1
## Latitude            1             1             1
## Year                1             1             1
##              Catenotaenia_pusilla Status Heterakis_sp N_oocysts_sq1
## MC.Eimeria          1             1             1             1
## delta_ct_cewe_MminusE 1             1             1             1

```

```

## Sex 1 1 1 1
## Longitude 1 1 1 1
## Latitude 1 1 1 1
## Year 1 1 1 1
## N_oocysts_sq2 N_oocysts_sq3 N_oocysts_sq4 N_oocysts_sq5
## MC.Eimeria 1 1 1 1
## delta_ct_cewe_MminusE 1 1 1 1
## Sex 1 1 1 1
## Longitude 1 1 1 1
## Latitude 1 1 1 1
## Year 1 1 1 1
## N_oocysts_sq6 N_oocysts_sq7 N_oocysts_sq8 Region
## MC.Eimeria 1 1 1 1
## delta_ct_cewe_MminusE 1 1 1 1
## Sex 1 1 1 1
## Longitude 1 1 1 1
## Latitude 1 1 1 1
## Year 1 1 1 1
## Body_Length Fleas Tail_Length eimeriaSpecies Ct.Eimeria
## MC.Eimeria 1 1 1 1 1
## delta_ct_cewe_MminusE 1 1 1 1 1
## Sex 1 1 1 1 1
## Longitude 1 1 1 1 1
## Latitude 1 1 1 1 1
## Year 1 1 1 1 1
## Ct.Mus ILWE_Crypto_Ct Aspicularis_sp Syphacia_sp
## MC.Eimeria 1 1 1 1
## delta_ct_cewe_MminusE 1 1 1 1
## Sex 1 1 1 1
## Longitude 1 1 1 1
## Latitude 1 1 1 1
## Year 1 1 1 1
## Taenia_sp Hymenolepis_sp FEC_Eim_Ct Treg CD4 Treg17 Th1
## MC.Eimeria 1 1 1 1 1 1 1
## delta_ct_cewe_MminusE 1 1 1 1 1 1 1
## Sex 1 1 1 1 1 1 1
## Longitude 1 1 1 1 1 1 1
## Latitude 1 1 1 1 1 1 1
## Year 1 1 1 1 1 1 1
## Th17 CD8 Act_CD8 IFNy_CD4 IL17A_CD4 IFNy_CD8 IFNy CXCR3
## MC.Eimeria 1 1 1 1 1 1 1
## delta_ct_cewe_MminusE 1 1 1 1 1 1 1
## Sex 1 1 1 1 1 1 1
## Longitude 1 1 1 1 1 1 1
## Latitude 1 1 1 1 1 1 1
## Year 1 1 1 1 1 1 1
## IL.6 IL.13 IL.10 IL1RN CASP1 CXCL9 IDO1 IRGM1 MPO MUC2
## MC.Eimeria 1 1 1 1 1 1 1 1 1 1
## delta_ct_cewe_MminusE 1 1 1 1 1 1 1 1 1 1
## Sex 1 1 1 1 1 1 1 1 1 1
## Longitude 1 1 1 1 1 1 1 1 1 1
## Latitude 1 1 1 1 1 1 1 1 1 1
## Year 1 1 1 1 1 1 1 1 1 1
## MUC5AC MYD88 NCR1 PRF1 RETNLB SOCS1 TICAM1 TNF

```

```

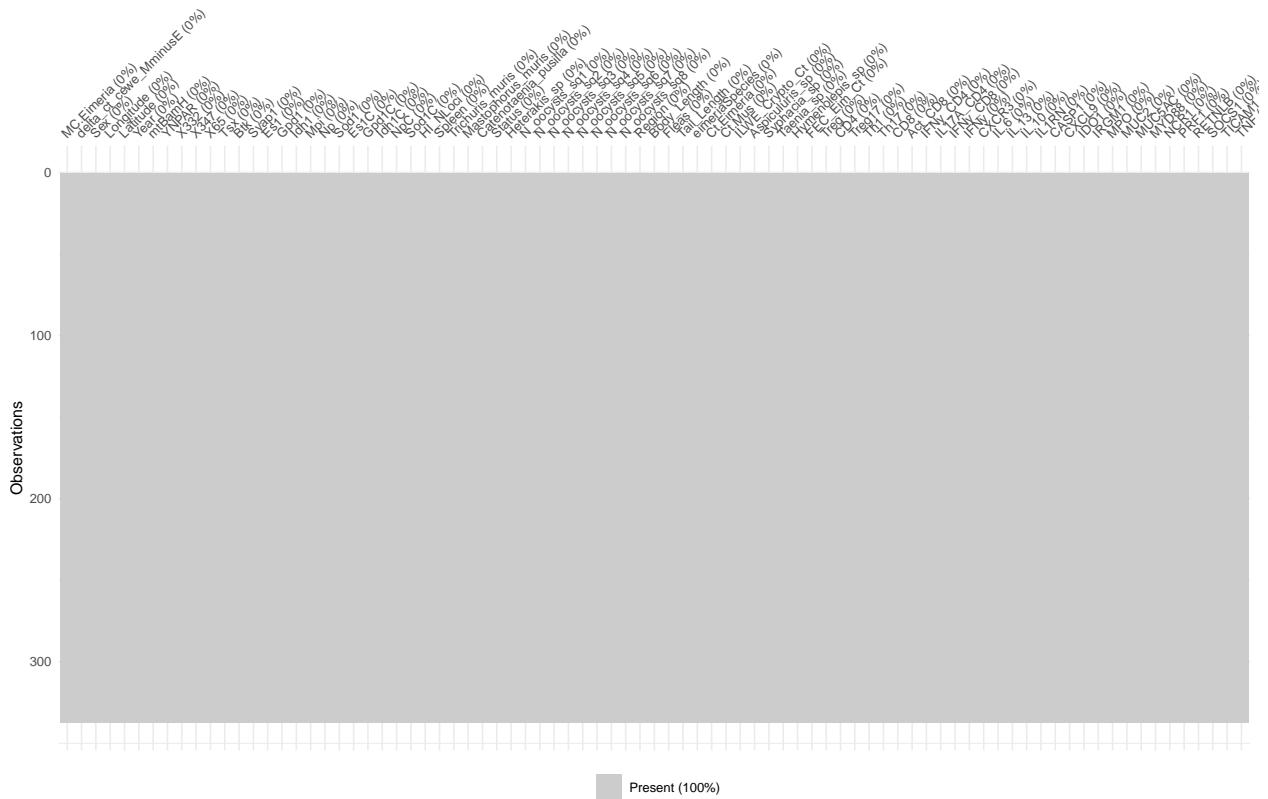
## MC.Eimeria          1   1   1   1   1   1   1   1
## delta_ct_cewe_MminusE 1   1   1   1   1   1   1   1
## Sex                 1   1   1   1   1   1   1   1
## Longitude           1   1   1   1   1   1   1   1
## Latitude            1   1   1   1   1   1   1   1
## Year                1   1   1   1   1   1   1   1
## Number of logged events: 3065
##   it im          dep     meth
## 1 1 1          MC.Eimeria logreg
## 2 1 1 delta_ct_cewe_MminusE pmm
## 3 1 1 delta_ct_cewe_MminusE pmm
## 4 1 1          mtBamH polyreg
## 5 1 1          YNPAR polyreg
## 6 1 1          YNPAR polyreg
##
## 1                      SexM, mtBamH , X332d/d, X332d/m, X332dm, X332m, X332m/m, X347d/d, X347d/m, X347dm/m
## 2 SexF, SexM, mtBamH , YNPARm, X332d/d, X332d/m, X332dm, X332m/m, X347d/d, X347d/m, X347dm, X347m/m
## 3
## 4
## 5
## 6                      SexM, mtBamH , X332d, X332d/m, X332dm, X332m, X332m/m, X347d/d, X347d/m, X347dm, X347m/m

# to check each column with imputed data
## igf$imp$IFNy

#Now we can get back the completed dataset using the complete()
complete_field <- complete(igf, 1)

#visualize missingness
vis_miss(complete_field)

```



```
#sapply(complete_field, function(x) sum(is.na(x)))

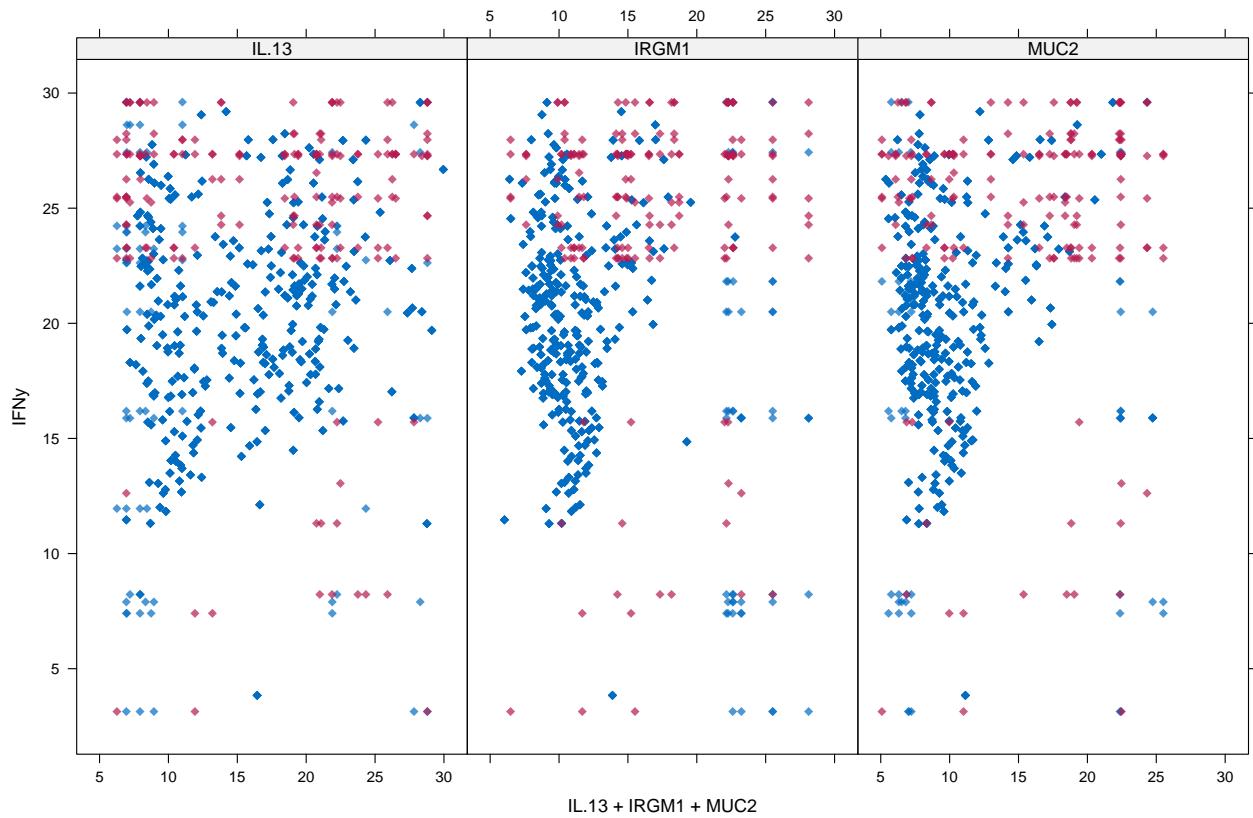
# select the required columns
imp_field <- complete_field %>%
  dplyr::select(all_of(c(Facs_wild, Genes_wild)))

#add an ending to the imputed columns
colnames(imp_field) <- paste(colnames(imp_field), "imp", sep = "_")

#now join it to the full data set of the laboratory infections
field <- cbind(f1, imp_field)
```

Let's compare the distributions of original and imputed data using some useful plots. First of all we can use a scatterplot and plot Ozone against all the other variables. Let's first plot the variables for which we have few missing values.

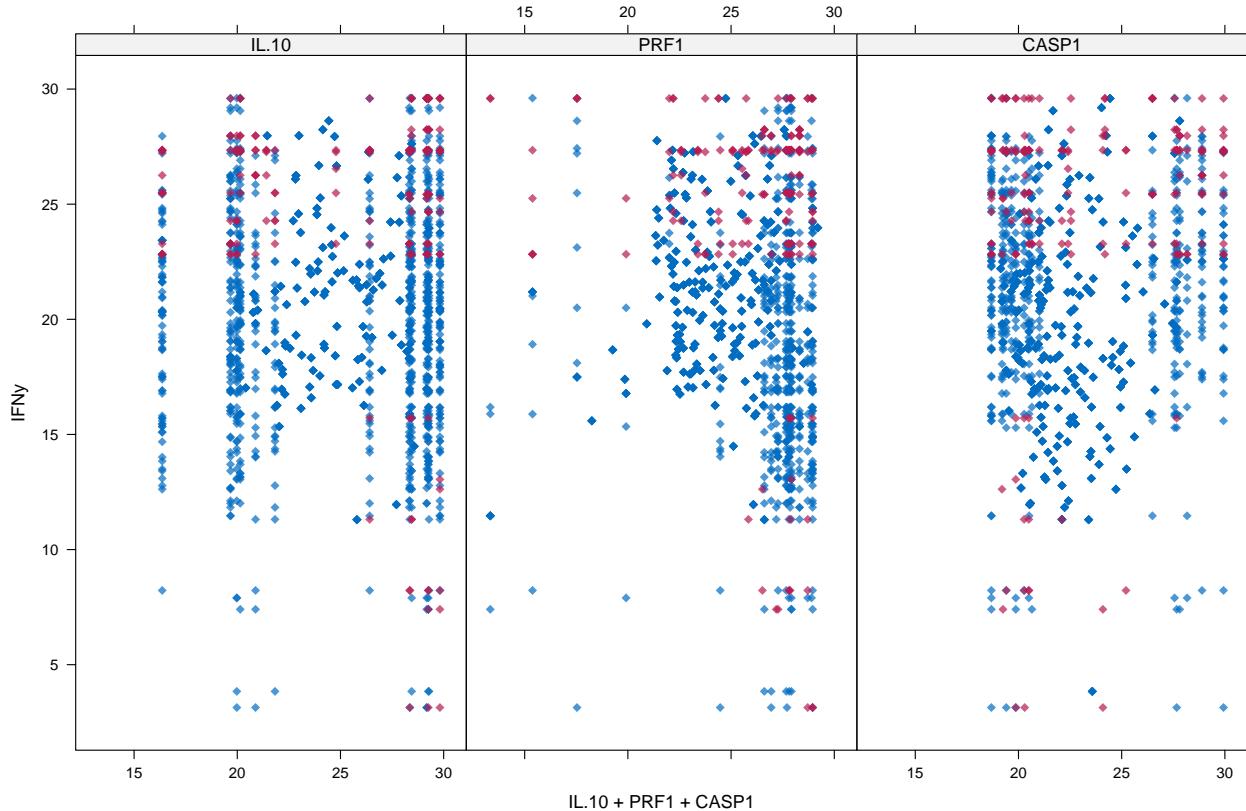
```
xyplot(igf, IFNy ~ IL.13 + IRGM1 + MUC2, pch=18, cex=1)
```



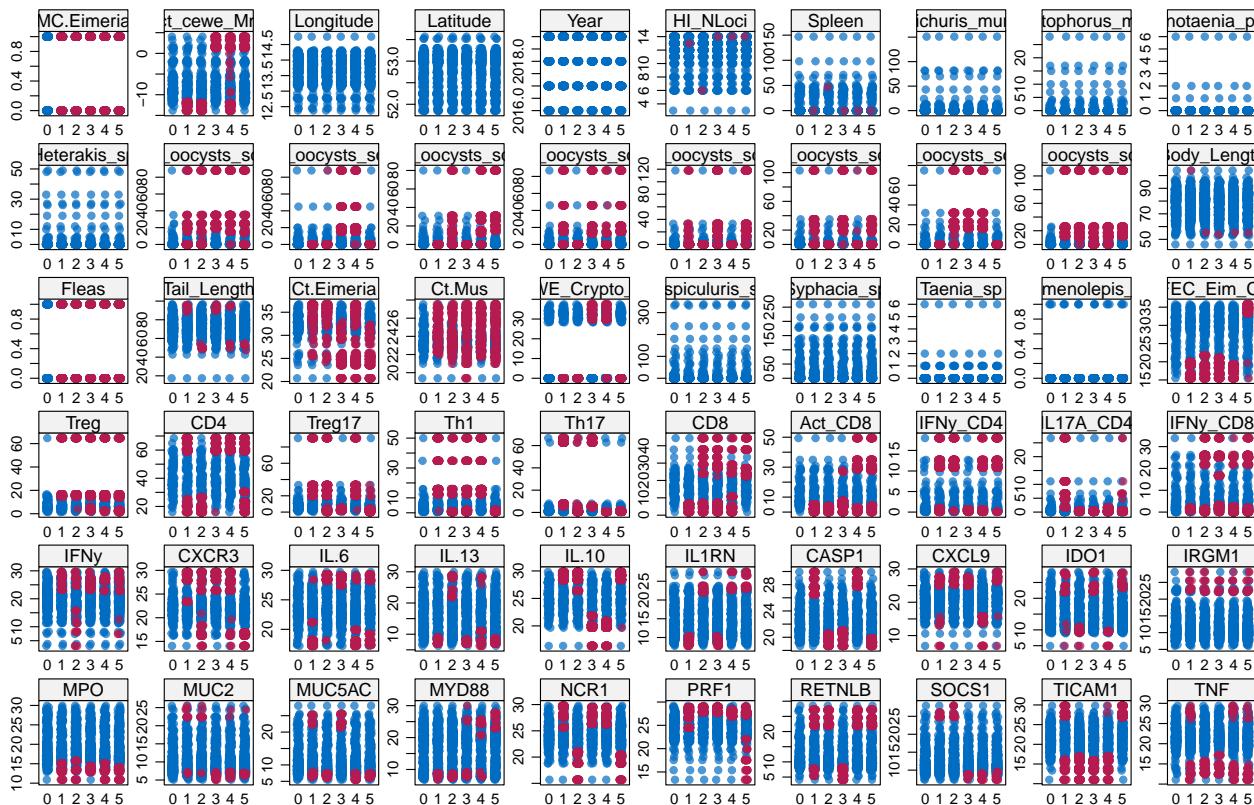
What we would like to see is that the shape of the magenta points (imputed) matches the shape of the blue ones (observed). The matching shape tells us that the imputed values are indeed “plausible values”.

Now let's plot the variables with many missing data points.

```
xyplot(igf,IFNy ~ IL.10 + PRF1 + CASP1, pch=18,cex=1)
```



```
stripplot(igf, pch = 20, cex = 1.2)
```



```
#densityplot(igf)
```

The density of the imputed data for each imputed dataset is showed in magenta while the density of the observed data is showed in blue. Again, under our previous assumptions we expect the distributions to be similar.

Another useful visual take on the distributions can be obtained using the `stripplot()` function that shows the distributions of the variables as individual points

Joining the two data frames for further analysis

```
# ow join the two data sets
imputed_hm <- full_join(f1, lab,
                         by = intersect(colnames(f1), colnames(lab)))

imputed_hm <- unique(imputed_hm)

##save the imputed data
write.csv(imputed_hm, "output_data/imputed_MICE.csv", row.names = FALSE)
```