FCL and motif

In this notebook, we analyze the relationship between FCL and the fractions of the motives in empirical food webs. We use igraph package to analyze food webs. To measure the fractions of the motives we use triad_census function in igraph. Note that 13 motives are defined but this function returns 16 motives because the function can include sub-graphs that include isolated nodes. Such sub-graphs are removed in the analysis. We use the database from Cohen (2011), whioch contains 213 empirical food webs.

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --
## v ggplot2 3.4.0      v purrr   0.3.5
## v tibble  3.1.8      v dplyr   1.0.10
## v tidyr   1.2.1      v stringr 1.4.1
## v readr   2.1.3      v forcats 0.5.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(igraph)
```

```
##
## Attaching package: 'igraph'
##
## The following objects are masked from 'package:dplyr':
##
##     as_data_frame, groups, union
##
## The following objects are masked from 'package:purrr':
##
##     compose, simplify
##
## The following object is masked from 'package:tidyr':
##
##     crossing
##
## The following object is masked from 'package:tibble':
##
##     as_data_frame
##
## The following objects are masked from 'package:stats':
##
##     decompose, spectrum
##
## The following object is masked from 'package:base':
##
##     union
```

```
FCL=function(A, def=0){
  # A: an adjacency matrix of directed food web
```

```
  # def: definition of FCL. We choose one definition from below
  # def =-1: shortest-path
  # def =0 (default)  mean trophic levels of prey +1. Only acyclic graph
  # def = 1: longest-path. Only acyclic graph

  N = nrow(A) # number of species in the food web
  TL=rep(0, N)
  B=c()
  # Check the indexes of basal species
  for (i in 1:N){
    if (sum(A[, i])==0){
      TL[i]=1 # basal species
      B=c(B, i) # list of basal species
    }
  }

  # Check whether A is DAG or not
  # calculate trophic levels


  for (i in 1:N){
    if(TL[i]==0){
      # analyze nob-basal species
      if (def==0){
          # we define FCL by mean prey's tropic level
          TL[i] = 1+(TL[1:(i-1)]%*%A[1:(i-1), i])/sum(A[1:(i-1), i])
      }
      else if (def==-1){
          # TL of species i is defined by 1+the shortest path from a basal species
          graph=graph_from_adjacency_matrix(A,mode='directed')
          TL[i] = 1+min(distances(graph,to = i, mode='out')[B])
      }
      else if (def==1){
          #TL of species i is defined by 1+the longest path from a basal species
          # Because igraph does not have an algorithm for the longest path
          # we will use the shortest path with negative weights
          graph=graph_from_adjacency_matrix(-A,mode='directed', weight=TRUE)
          TL[i] =1- min(distances(graph,to = i, mode='out')[B]) # we only care distances from basal spe
      }
    }
  }
 #print(TL)
  return (max(TL)-1) # FCL= max TL -1
}
```

```
# define A

# read from Data base
# NOTE THAT WE NEED TO CHANGE SEPARATOR IN THE FILES
# Unfortunately, we CANNOT define FCL based  on prey's trophic levels
# because the species's induces are not sorted so that an adj matrix is upper-triangular.
# and because we do not know an algorithm to sort the species induces.
Analysis = function (d){
  # d row csv file
```

```
# return FCLs and number fo the motives
D=d[, 4:ncol(d)]
#rownames(D)=d[, 3]
#colnames(D)=d[1,4:ncol(d) ]
A=data.frame(D)
colnames(A)=colnames(D)
rownames(A)=as.character(unlist(d[, 3]))
for (i in 1:nrow(A)){
  if (as.integer(rownames(A))[i]<10){
    rownames(A)[i] = paste0("0",rownames(A)[i])
  }
}

for (i in 1:ncol(A)){
  if (as.integer(colnames(A))[i]<10){
    colnames(A)[i] = paste0("0",colnames(A)[i])
  }
}
# We need to convert a data into NxN matrix
N_list=sort(unique(c(rownames(A), colnames(A)))) # total number of species in the food web
col_check=!(N_list %in% colnames(A)) # which species is missing in columns?
row_check=!(N_list %in% rownames(A)) # which species is missing in rows?
for(i in 1:length(N_list)){
  if (col_check[i]==TRUE){
     add = rep(0, nrow(A))
     a=cbind(A, add)
     #if(i<10){
     #  colnames(a)=c(colnames(A), paste0("0",N_list[0]))
     #}else{
      # colnames(a)=c(colnames(A), paste0(N_list[i]))
     #}
     colnames(a)=c(colnames(A), paste0(N_list[i]))
     A= a %>% select(all_of(names(a) %>% sort())) # update A and sorting
  }
  if (row_check[i]==TRUE){
     add = rep(0, ncol(A))
     a=rbind(A, add)
     #if(i<10){
    #   rownames(a)=c(rownames(A), paste0("0",N_list[i]))
    # }else{
     #  rownames(a)=c(rownames(A), paste0(N_list[i]))
     #}
     rownames(a)=c(rownames(A), paste0(N_list[i]))
     A=a %>% arrange(rownames(a)) # update A and sorting
  }
}
A=matrix(unlist(A), ncol=ncol(A))  # convert matrix so that we can use it in igraph
graph=graph_from_adjacency_matrix(A,mode='directed')
if (is.dag(graph)==TRUE){
  #FCL_mean=FCL(A, def=0) # FCL based on mean prey trophic level
  # convert weighted adj into unweighted one
  A =matrix(as.integer(A>0), nrow=nrow(A))
  FCL_long = FCL(A, 1)
```

```
  }else{
  # In this case, two FCLs cannot be defined
  #FCL_mean=NaN
  FCL_long=NaN
  # convert weighted adj into unweighted one
  A =matrix(as.integer(A>0), nrow=nrow(A))
  }
  FCL_short =FCL(A, -1) # this can be defined in any food webs. Return Inf without basal species

  motif=matrix(triad_census(graph), nrow=1)
  # the names of the motives follow previous studies
  data=data.frame(FCL_short, FCL_long, nrow(A), motif)
  colnames(data) = c('FCL_short', 'FCL_long',"richness",
                     "empty","monoA-single","bi-single",
                     "s5","s4","s1","d4","d3","s2",
                     "s3","d8","d2","d1","d5","d7","d6")
  return (data)
}
```

```
#Main
# Note that we used the cleaned data from the database so that we can easily analyze them in R
# We do not calcualte FCL_mean heere because adj matrix does not necesarily upper-triangular although i
for(i in 1:213){
  fname=paste0('./EmpiricalFoodWeb/ECOWeB1.1/DATFILES Predation Matrices/WEB',i,'.DAT')
  d=read_csv(fname)
  if (i==1){
  data=Analysis(d)
  }else{
    data=rbind(data, Analysis(d))
  }
write.csv(data, "Cohen2010_summary.csv", row.names = FALSE)
}
```

```
## New names:
## Rows: 8 Columns: 10
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 3, 4, 5, 6, 7, 8, 9 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 13 Columns: 15
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 15 Columns: 23
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (21): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
```

```
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 5 Columns: 7
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (5): ID, 2, 3, 6, 7 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 16 Columns: 26
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (24): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 2... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 16 Columns: 20
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (18): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 lgl (2):
## ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 3, 4, 5, 6, 7, 8, 9, 10 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 4 Columns: 6
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (4): ID, 3, 4, 5 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 8
```

```
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (6): ID, 4, 5, 6, 7, 8 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 6 Columns: 10
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 2, 3, 4, 5, 6, 7, 8 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 2, 3, 4, 5, 6, 7, 8, 9 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 12 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 18 Columns: 22
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (20): ID, 3, 4, 5, 6, 7, 8, 9, 11, 12, 14, 15, 16, 21, 22, 23, 24, 25, 2... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
```

```
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 12 Columns: 18
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (16): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 lgl (2): ...1,
## ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 14 Columns: 19
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (17): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 lgl (2):
## ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 10
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 4, 5, 6, 7, 8, 9, 10 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 23 Columns: 25
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (23): ID, 2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 17
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (15): ID, 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## * `` -> `...1`
## * `` -> `...2`
## Warning: One or more parsing issues, call `problems()` on your data frame for details,
## e.g.:
##   dat <- vroom(...)
##   problems(dat)
## Rows: 8 Columns: 10
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (1): 12
## dbl (7): 2, 3, 4, 7, 8, 9, 10
## lgl (2): ...1, ID
##
```

```
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.

## Warning in mde(x): NAs introduced by coercion

## New names:
## Rows: 17 Columns: 25
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (23): ID, 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 21... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 27 Columns: 28
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (26): ID, 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20, 22... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 16 Columns: 21
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (19): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 17 Columns: 41
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (39): ID, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, ... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 23
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (21): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 2... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 12 Columns: 16
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (14): ID, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 13 Columns: 15
## -- Column specification
```

```
## ------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 13 Columns: 15
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 15 Columns: 31
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (29): ID, 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 11
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 14
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 13 Columns: 17
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (15): 36, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 lgl (2): ...1,
## ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 12 Columns: 27
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (25): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 14 Columns: 31
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (29): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
```

```
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 17 Columns: 35
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (33): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 6 Columns: 12
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (10): ID, 2, 3, 4, 5, 7, 8, 9, 10, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 17 Columns: 20
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (18): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 lgl (2):
## ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 15 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 16 Columns: 20
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (18): 43, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 12
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (10): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
```

```
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 17 Columns: 15
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 23 Columns: 27
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (25): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, ... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 12
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (10): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 15
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 21 Columns: 24
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (22): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 23
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (21): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 2... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
```

```
## Rows: 13 Columns: 23
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (21): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 2... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 13 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 6 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 9
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (7): ID, 4, 5, 6, 7, 8, 9 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 14 Columns: 16
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (14): ID, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 22 Columns: 27
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (25): ID, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 2... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 22 Columns: 31
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
```

```
## (29): ID, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 5 Columns: 10
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 3, 4, 5, 6, 7, 8, 9 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 12
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (10): 62, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 16 Columns: 16
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (14): 63, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 20
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (18): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 lgl (2):
## ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 17
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (15): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 10
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 4, 5, 6, 7, 8, 9, 10 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 19 Columns: 22
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (20): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 2... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
```

```
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 13 Columns: 21
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (19): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 24 Columns: 28
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (26): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 15
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 15 Columns: 16
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (14): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 15 Columns: 15
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 9
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (7): ID, 5, 6, 7, 8, 9, 10 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 15 Columns: 22
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (20): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 2... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
```

```
## Rows: 8 Columns: 9
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (7): ID, 4, 5, 6, 7, 8, 9 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 12 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 13 Columns: 17
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (15): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 17 Columns: 21
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (19): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 21 Columns: 25
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (23): ID, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
```

```
## (9): ID, 3, 4, 5, 6, 7, 8, 9, 10 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 20 Columns: 24
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (22): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 23 Columns: 22
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (20): ID, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 15 Columns: 17
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (15): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 6 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 15
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 15 Columns: 17
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (15): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
## New names:
## Rows: 9 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 3, 4, 5, 6, 7, 8, 9, 10 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 3, 4, 5, 6, 7, 8, 9, 10 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 18
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (16): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 lgl (2): ...1,
## ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 15 Columns: 28
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (26): ID, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 12
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (10): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 3, 4, 5, 6, 7, 8, 9, 10 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 5 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 2, 3, 4, 5, 6, 7, 8, 9 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 6 Columns: 12
## -- Column specification
```

```
## ------------------------------------------------------- Delimiter: "," dbl
## (10): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 14 Columns: 16
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (14): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 31 Columns: 42
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (40): ID, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 17 Columns: 20
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (18): ID, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 4 Columns: 7
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (5): ID, 3, 4, 5, 6 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 10
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 3, 4, 5, 6, 7, 8, 9 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 21 Columns: 22
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (20): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 21 Columns: 28
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (26): ID, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 2... lgl
```

```
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 3, 4, 5, 6, 7, 8, 9, 10 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 25 Columns: 35
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (33): ID, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 3, 4, 5, 6, 7, 8, 9, 10 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 17 Columns: 21
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (19): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 13 Columns: 18
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (16): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 lgl (2): ...1,
## ...2
## i Use `spec()` to retrieve the full column specification for this data. i
```

```
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 10
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 5, 6, 7, 8, 9, 10, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 17
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (15): ID, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 lgl (2): ...1,
## ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 26 Columns: 42
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (40): ID, 7, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, ... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 6 Columns: 9
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (7): ID, 2, 3, 4, 5, 6, 7 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 12 Columns: 12
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (10): ID, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 10
```

```
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 5, 6, 7, 8, 9, 10, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 12 Columns: 16
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (14): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 12
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (10): ID, 2, 4, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 4 Columns: 10
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 6, 7, 8, 9, 11, 14, 15 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 113 Columns: 39
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (37): ID, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 90... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 6 Columns: 10
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 3, 6, 7, 8, 9, 10, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 9
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (7): ID, 4, 5, 6, 7, 8, 9 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 21 Columns: 21
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (19): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 19, 22, 23, 24, 25, 26, 27 lgl
## (2): ...1, ...2
```

```
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 16
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (14): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 15
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 12 Columns: 19
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (17): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 lgl (2): ...1,
## ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 14 Columns: 18
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (16): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 4 Columns: 9
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (7): ID, 1, 2, 3, 4, 5, 6 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 11
```

```
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 1, 2, 3, 4, 5, 6, 7, 8 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 3 Columns: 6
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (4): ID, 1, 2, 3 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 3 Columns: 7
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (5): ID, 1, 2, 3, 4 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 11
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 1, 2, 3, 4, 5, 6, 7, 8 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 3 Columns: 9
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (7): 138, 1, 2, 3, 4, 5, 6 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 12
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (10): ID, 1, 2, 3, 4, 5, 6, 7, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 3 Columns: 7
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (5): ID, 1, 2, 3, 4 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 4 Columns: 8
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (6): ID, 1, 2, 3, 4, 5 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
## New names:
## Rows: 3 Columns: 7
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (5): ID, 1, 2, 3, 4 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 12
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (10): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 3 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 1, 2, 3, 4, 5, 6, 7, 8 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 15
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 12 Columns: 26
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (24): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 5 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 5 Columns: 15
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 6 Columns: 10
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
```

```
## (8): ID, 1, 2, 3, 4, 5, 6, 7 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 6 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 1, 2, 3, 4, 5, 6, 7, 8 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 19 Columns: 24
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (22): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 25
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (23): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 5 Columns: 9
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (7): ID, 1, 2, 3, 4, 5, 6 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 17
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (15): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 18
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (16): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 4 Columns: 16
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (14): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
## New names:
## Rows: 6 Columns: 9
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (7): ID, 1, 2, 3, 4, 5, 6 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 2 Columns: 5
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (3): ID, 1, 2 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 3 Columns: 10
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 1, 2, 3, 4, 5, 6, 7 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 16
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (14): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): X, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 2 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 1, 2, 3, 4, 5, 6, 7, 8 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 2 Columns: 5
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (3): ID, 1, 2 lgl (2): ...1, ...2
```

```
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 3 Columns: 8
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (6): ID, 1, 2, 3, 4, 5 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 5 Columns: 13
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (11): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 39 Columns: 64
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (62): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 22 Columns: 38
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (36): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 24 Columns: 39
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (37): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 15
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (13): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 1, 2, 3, 4, 5, 6, 7, 8 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
## New names:
## Rows: 7 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 8 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): 173, 1, 2, 3, 4, 5, 6, 7, 8 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 14
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (12): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 11 Columns: 21
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (19): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 15 Columns: 26
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (24): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 6 Columns: 11
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (9): ID, 1, 2, 3, 4, 5, 6, 7, 8 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 11
## -- Column specification
```

```
## ------------------------------------------------------- Delimiter: "," dbl
## (9): 179, 1, 2, 3, 4, 5, 6, 7, 8 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 21 Columns: 48
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (46): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 20 Columns: 89
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (87): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 37 Columns: 90
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (88): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 12 Columns: 38
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (36): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 16 Columns: 22
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (20): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 4 Columns: 34
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (32): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 5 Columns: 24
```

```
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (22): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 21, 22,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 37 Columns: 46
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (44): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 4 Columns: 29
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (27): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 2 Columns: 20
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (18): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 lgl (2):
## ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 3 Columns: 10
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (8): ID, 1, 2, 3, 4, 5, 6, 7 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 22 Columns: 29
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (27): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 1 Columns: 8
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (6): ID, 1, 2, 3, 4, 5 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 5 Columns: 23
```

```
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (21): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 1 Columns: 5
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (3): ID, 1, 2 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 12 Columns: 26
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (24): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 4 Columns: 16
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (14): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 19
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (17): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 lgl (2): ...1,
## ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 7 Columns: 30
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (28): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 27 Columns: 12
## -- Column specification
## -------------------------------------------------------- Delimiter: "," dbl
## (10): 199, 1, 2, 4, 5, 6, 7, 8, 9, 31 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 14 Columns: 28
## -- Column specification
```

```
## ------------------------------------------------------- Delimiter: "," dbl
## (26): 200, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 18 Columns: 37
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (35): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 18 Columns: 7
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (5): 202, 1, 10, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 10 Columns: 17
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (15): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 15 Columns: 31
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (29): ID, 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 20 Columns: 23
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (21): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 21 Columns: 25
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (23): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 26 Columns: 18
## -- Column specification
```

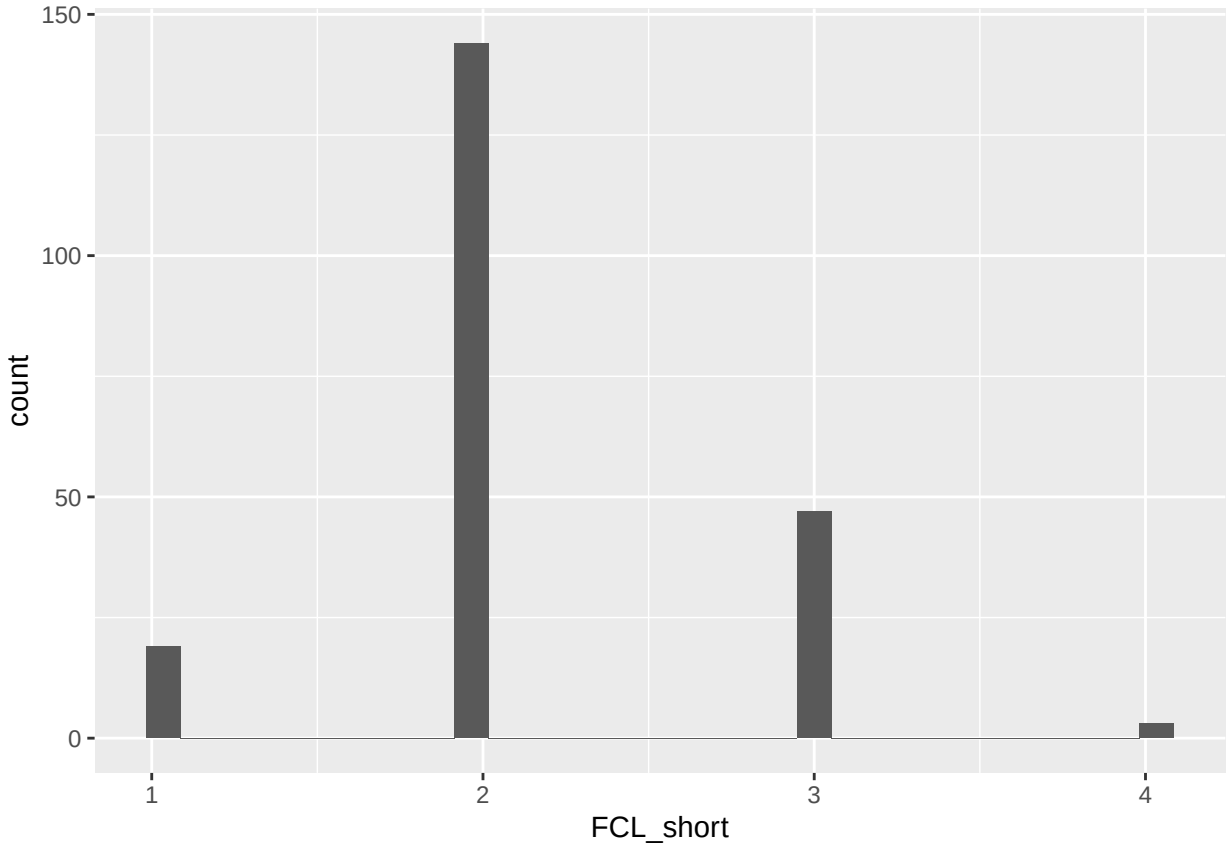
```
## ------------------------------------------------------- Delimiter: "," dbl
## (16): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 9 Columns: 12
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (10): ID, 1, 2, 3, 4, 5, 6, 7, 8, 11 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 18 Columns: 24
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (22): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 41 Columns: 56
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (54): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 33 Columns: 17
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (15): ID, 1, 2, 3, 4, 5, 9, 10, 11, 12, 13, 14, 15, 25, 26 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 21 Columns: 10
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (8): IDs, 1, 2, 3, 4, 5, 6, 7 lgl (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## New names:
## Rows: 20 Columns: 29
## -- Column specification
## ------------------------------------------------------- Delimiter: "," dbl
## (27): ID, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,... lgl
## (2): ...1, ...2
## i Use `spec()` to retrieve the full column specification for this data. i
## Specify the column types or set `show_col_types = FALSE` to quiet this message.
## * `` -> `...1`
## * `` -> `...2`
```

Below, we plot distributions of FCLs and richness, and a collaboration matrix. Some important variables: s1: chain motif, s2: omnivory motif, s3: cyclic predation motif (RSP game) s4 & 5: apparent or exploitative

competition motives (2 prey or 2 predators, respectively)

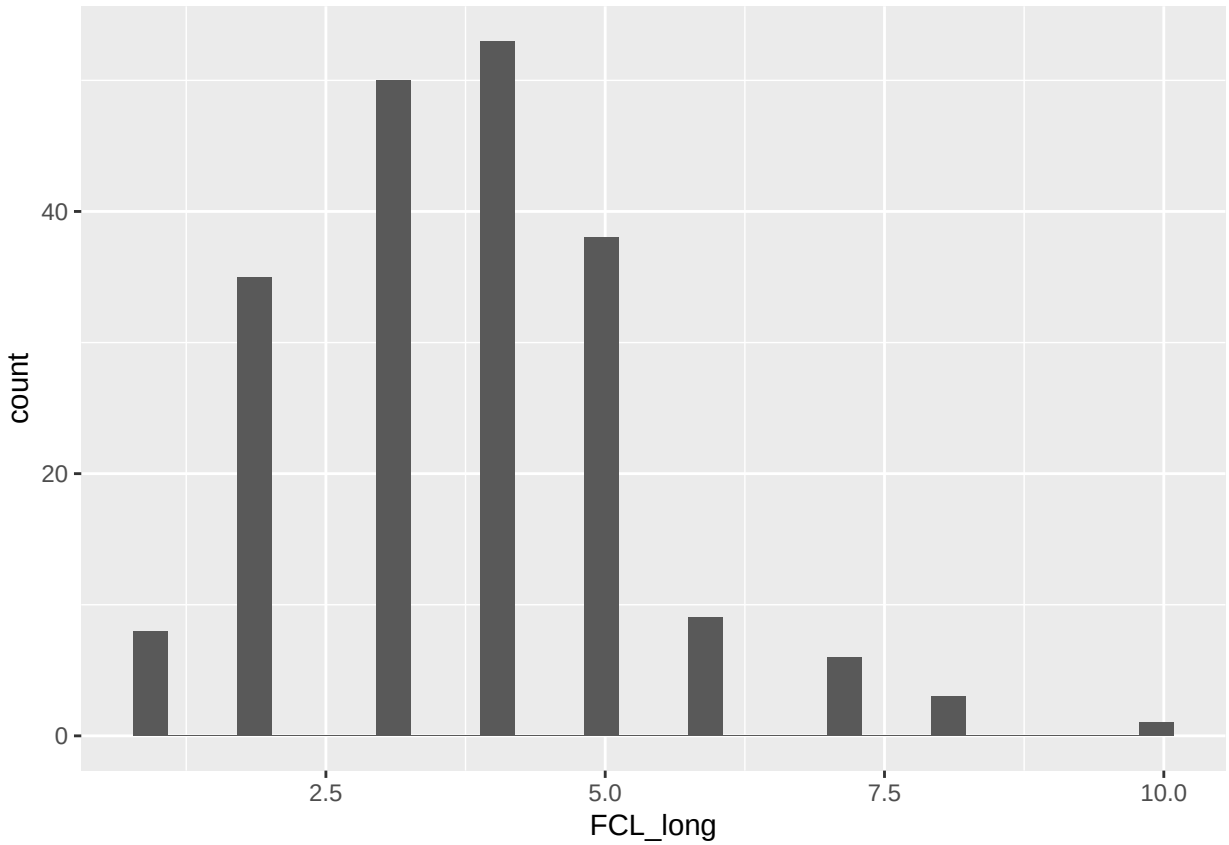
```
library(ggplot2)
library(tidyverse)
data=read.csv("Cohen2010_summary.csv") # this csv data summarizes the FCLs and the NUMBERS of fractions
# plot FCLs and richness
ggplot(data, aes(x=FCL_short)) + geom_histogram()
```

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



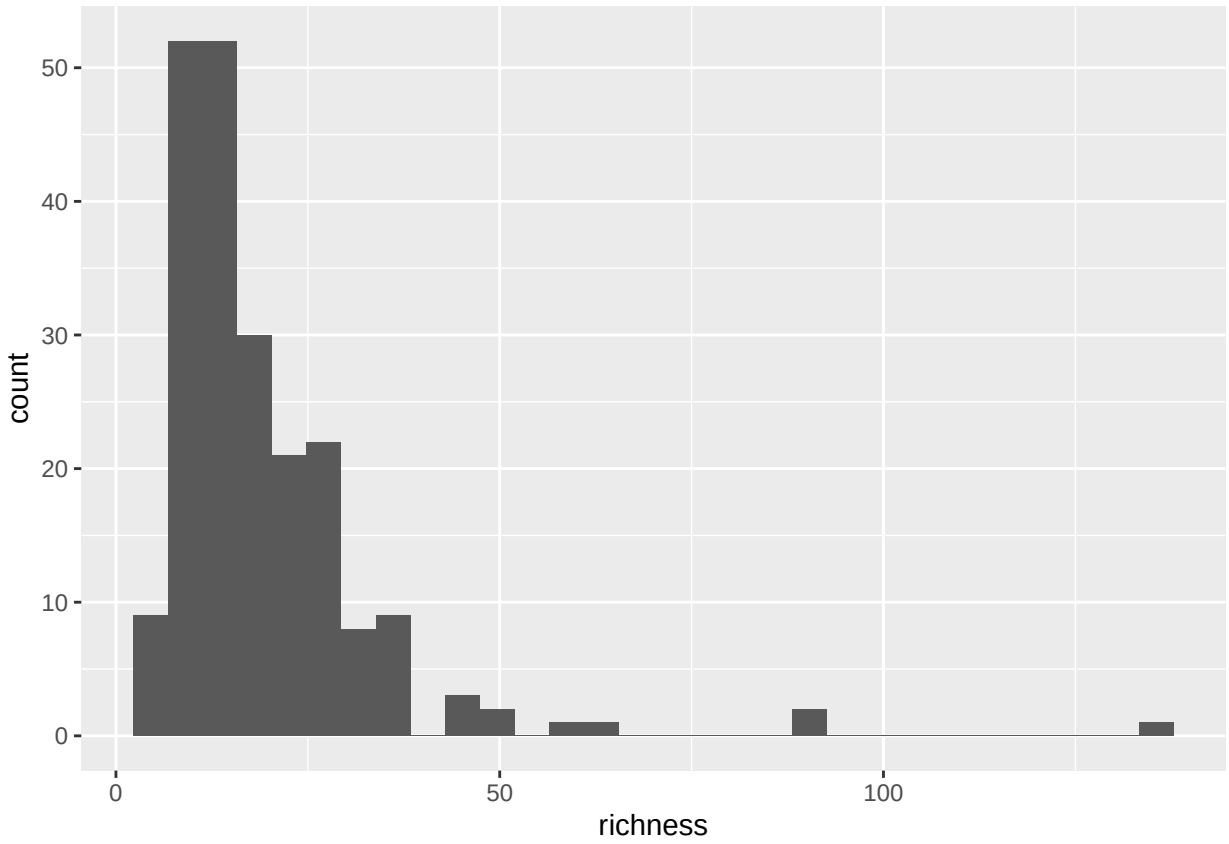

```
ggplot(data, aes(x=FCL_long)) + geom_histogram()
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## Warning: Removed 10 rows containing non-finite values (`stat_bin()`).
```




```
ggplot(data, aes(x=richness)) + geom_histogram()
```

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



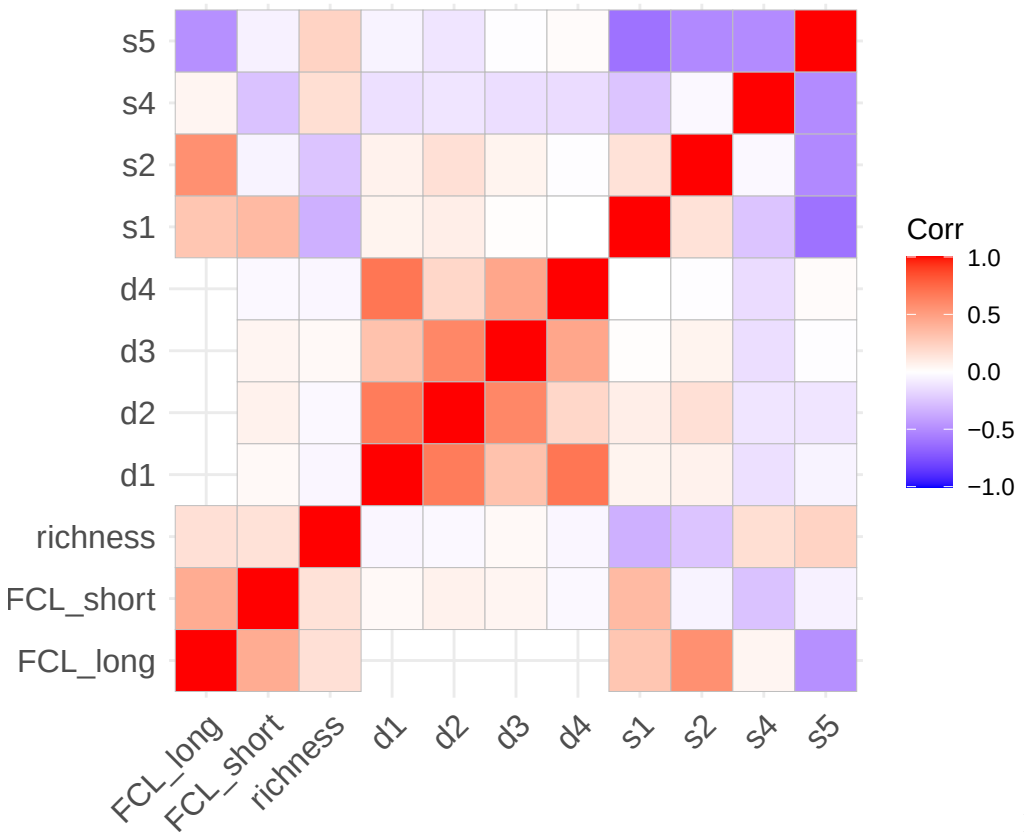

```
# remove empty, mono- and bi-single as they are not used in previous studies
df = subset(data, select = -c(empty,monoA.single, bi.single) )
df=df %>% select(order(colnames(df)))
df=dplyr::select(df, FCL_long,FCL_short,richness,everything())
head(df)
```

```
##   FCL_long FCL_short richness d1 d2 d3 d4 d5 d6 d7 d8 s1 s2 s3 s4 s5
## 1        4         2        9  0  0  0  0  0  0  0  0 19  4  0 12 13
## 2        3         2       15  0  0  0  0  0  0  0  0 27  0  0 26 29
## 3        3         2       24  0  0  0  0  0  0  0  0 31  2  0 16 28
## 4        4         2       13  0  0  0  0  0  0  0  0 19 10  0 18 24
## 5        2         2        7  0  0  0  0  0  0  0  0  4  0  0  3  1
## 6        6         4       25  0  0  0  0  0  0  0  0 49  3  0 33 58
```

```
# Below we analyze df. We may need to convert the numbers of the motives into their fractions
sum.motif=apply(df[, 4:ncol(df)], 1, sum) # sum of motives in each row
df[, 4:ncol(df)] = df[, 4:ncol(df)]/sum.motif # converting into fractions of motives
# we remove s3 and d5-d8 from the data frame because they  are missing in all data
#print(apply(df[, 4:ncol(df)], 2, sum))
df = subset(df, select = -c(s3, d5, d6, d7,d8) )
df[, 4:ncol(df)] = scale(df[,4:ncol(df)]) # this is scaled data.
# check correlation
library(ggcorrplot)
corr=cor(df, use = "pairwise.complete.obs") # pearson and spearman show similar results
```

```
## Warning in cor(df, use = "pairwise.complete.obs"): the standard deviation is
## zero
```

```
ggcorrplot(corr)
```



FCL_short is biased toward FCL_short=2 and the variation seems very small, which suggests that the analysis on FCL_short is not promising. IN contrast, FCL_long has a larger variation and we are likely to analyze how the fractions of the motives affect FCL_long. In addition, we have a variation in species richness, and we can remove the effect of richness on FCL_long in a stat model. In the correlation matrix, we can see positive correlations between FCL_long and s1 (chain), s2 (omnivory), and richness. This would be intuitive. In the chain and omnivory motives, FCL_long is two, while FCL_long of competition is one; then, having the chain or omnivory motives would inclurease FCL_long in the whole food web. In addition, if we have more species, we are likely to have longer FCL as the max FCL is richness minus one (when theb whole food web is chain).

Below, we will see some simple linear regressions. Note that we use the scaled variable so that means of richness and the fractions of the motives are zero while their sds are ones. This enables us to compare their "effects" on FCL_long (although, this is not the causal inference).

```
print('Shortest path length')
```

```
## [1] "Shortest path length"
```

```
summary(lm(formula = FCL_short ~ richness + s1 + s2 + s4+s5, data = df)) # we use ds as intercept
```

```
##
## Call:
## lm(formula = FCL_short ~ richness + s1 + s2 + s4 + s5, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.23288 -0.22864 -0.06577  0.22668  1.59078
##
```

```
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.916041   0.061099  31.360  < 2e-16 ***
## richness     0.012833   0.002639   4.862 2.29e-06 ***
## s1           0.335990   0.266582   1.260    0.209
## s2           0.031793   0.159994   0.199    0.843
## s4          -0.037997   0.255899  -0.148    0.882
## s5           0.124385   0.367331   0.339    0.735
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5104 on 207 degrees of freedom
## Multiple R-squared:  0.2568, Adjusted R-squared:  0.2389
## F-statistic: 14.31 on 5 and 207 DF,  p-value: 4.986e-12
```

```
print('Longest path length')
```

```
## [1] "Longest path length"
```

```
summary(lm(formula = FCL_long ~ richness + s1 + s2 + s5, data = df)) # we use s5 as intercept
```

```
##
## Call:
## lm(formula = FCL_long ~ richness + s1 + s2 + s5, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.8008 -0.5642 -0.0180  0.5478  4.1574
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  2.720535   0.138330  19.667  < 2e-16 ***
## richness     0.056024   0.006426   8.718 1.14e-15 ***
## s1           0.462549   0.095431   4.847 2.53e-06 ***
## s2           0.865266   0.088192   9.811  < 2e-16 ***
## s5          -0.223622   0.105030  -2.129   0.0345 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.015 on 198 degrees of freedom
##   (10 observations deleted due to missingness)
## Multiple R-squared:  0.5575, Adjusted R-squared:  0.5486
## F-statistic: 62.37 on 4 and 198 DF,  p-value: < 2.2e-16
```

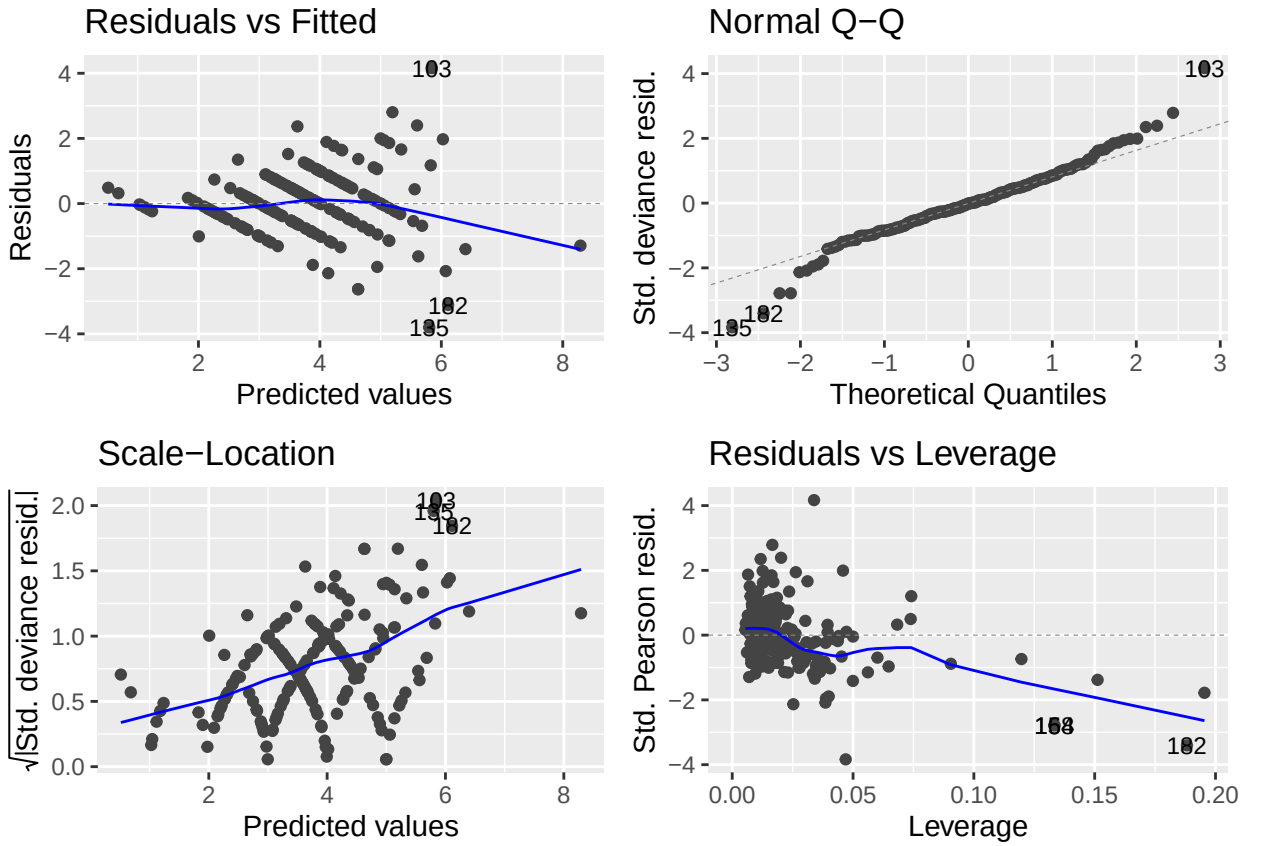
As the variations in FCL-short is small, the regression is not interesting as expected. In contrast, we can see the effects of the single-path motives on FCL_long. Let's us see next the comparisons between the prediction and acutual FCL_long. Note: linear regression would not be a good choice as FCL is discrete. Below we try some glms.

```
library(ggfortify)
model1=glm(FCL_long~richness+s1+s2+s5, data=df, family = 'gaussian') # gaussian
summary(model1)
```

```
##
## Call:
## glm(formula = FCL_long ~ richness + s1 + s2 + s5, family = "gaussian",
##     data = df)
```

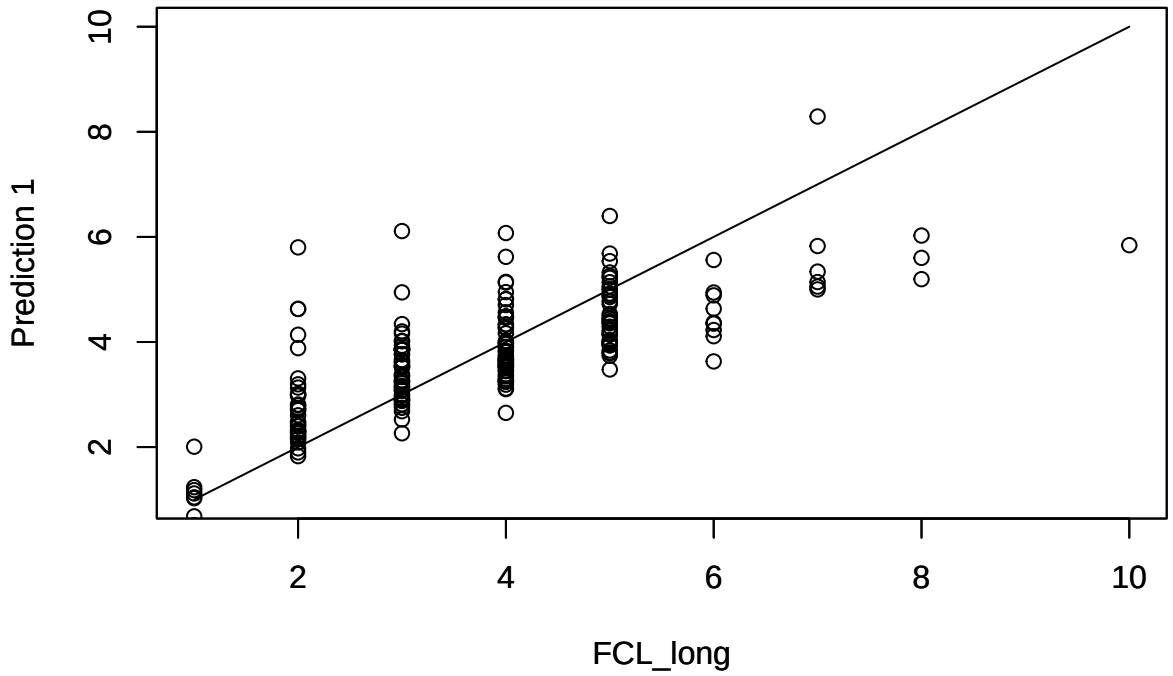
```
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.8008  -0.5642  -0.0180   0.5478   4.1574
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  2.720535   0.138330  19.667  < 2e-16 ***
## richness     0.056024   0.006426   8.718 1.14e-15 ***
## s1           0.462549   0.095431   4.847 2.53e-06 ***
## s2           0.865266   0.088192   9.811  < 2e-16 ***
## s5          -0.223622   0.105030  -2.129   0.0345 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 1.029531)
##
##     Null deviance: 460.68  on 202  degrees of freedom
## Residual deviance: 203.85  on 198  degrees of freedom
##   (10 observations deleted due to missingness)
## AIC: 588.93
##
## Number of Fisher Scoring iterations: 2
```

```
autoplot(model1, label.size = 3)
```




```
plot(data$FCL_long[-(which(is.na(data$FCL_long)))],predict(model1),
     xlab='FCL_long', ylab='Prediction 1',
```

```
     xlim=c(1,10), ylim=c(1, 10))
par(new=T)
plot(c(1:10), c(1:10), type='l',
      xlab='FCL_long', ylab='Prediction 1',
     xlim=c(1,10), ylim=c(1, 10))
```




```
# In case you want to check VIF, use the codes below
# library(car)
# barplot(vif(model1), main = "VIF Values", horiz = TRUE, col = "steelblue")
 # As we can see, VIFs are small
```

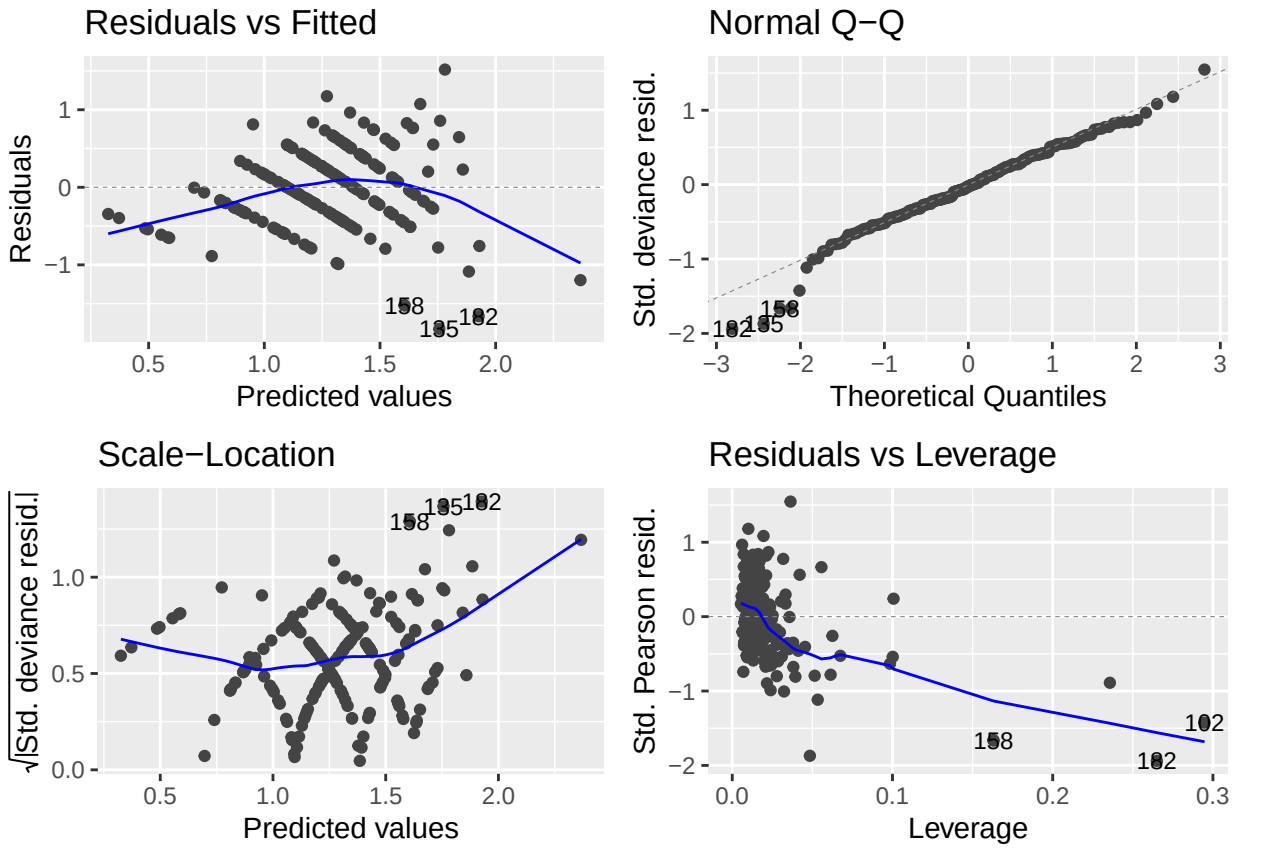
This model cannot predict long (>6) FCL_long How about Poisson? The mean of FZCL_long is 3.7 and its variance is 2.3, but this faily function cannot generate FCL>3

```
model2=glm(FCL_long~richness+s1+s2+s5, data=df, family = 'poisson') # poisson
summary(model2)
```

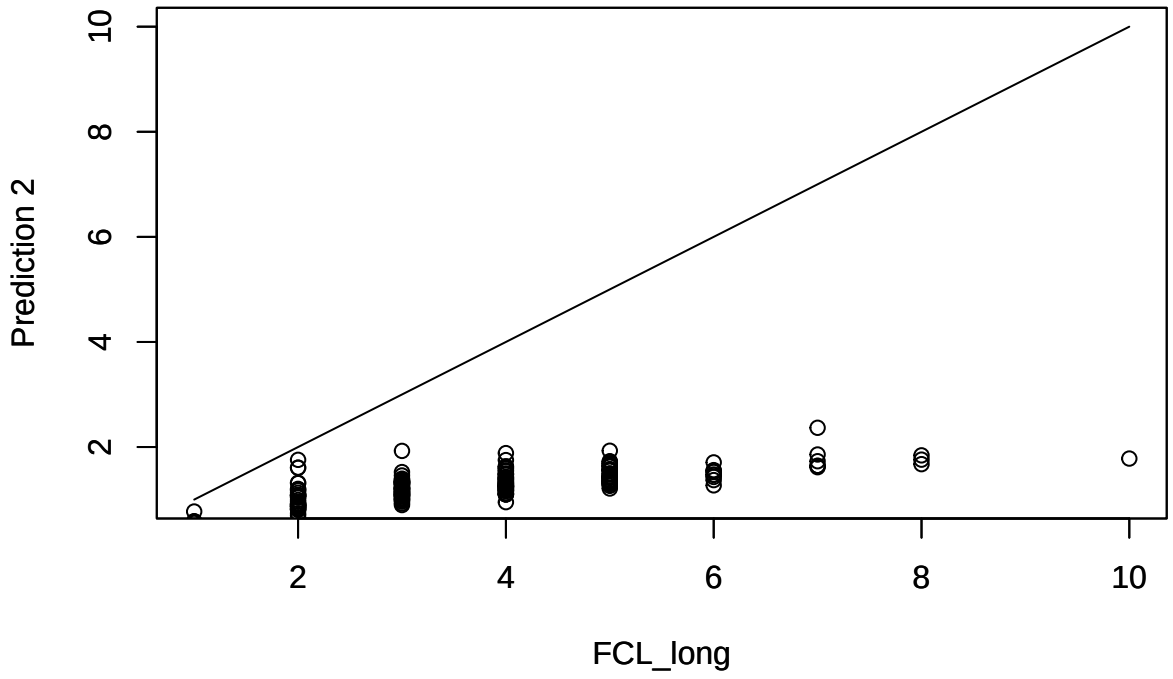
```
##
## Call:
## glm(formula = FCL_long ~ richness + s1 + s2 + s5, family = "poisson",
##     data = df)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -1.82476  -0.34340  -0.02955   0.33685   1.51808
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  0.991112   0.073140  13.551  < 2e-16 ***
## richness     0.015544   0.003041   5.111 3.20e-07 ***
## s1           0.123130   0.047707   2.581  0.00985 **
## s2           0.195404   0.039918   4.895 9.82e-07 ***
## s5          -0.098536   0.057653  -1.709  0.08743 .
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 122.260  on 202  degrees of freedom
## Residual deviance:  53.824  on 198  degrees of freedom
##   (10 observations deleted due to missingness)
## AIC: 697.98
##
## Number of Fisher Scoring iterations: 4
```

```
autoplot(model2, label.size = 3)
```




```
plot(data$FCL_long[-(which(is.na(data$FCL_long)))],predict(model2),
     xlab='FCL_long', ylab='Prediction 2',
     xlim=c(1,10), ylim=c(1, 10))
par(new=T)
plot(c(1:10), c(1:10), type='l',
      xlab='FCL_long', ylab='Prediction 2',
     xlim=c(1,10), ylim=c(1, 10))
```



Poisson is worse.

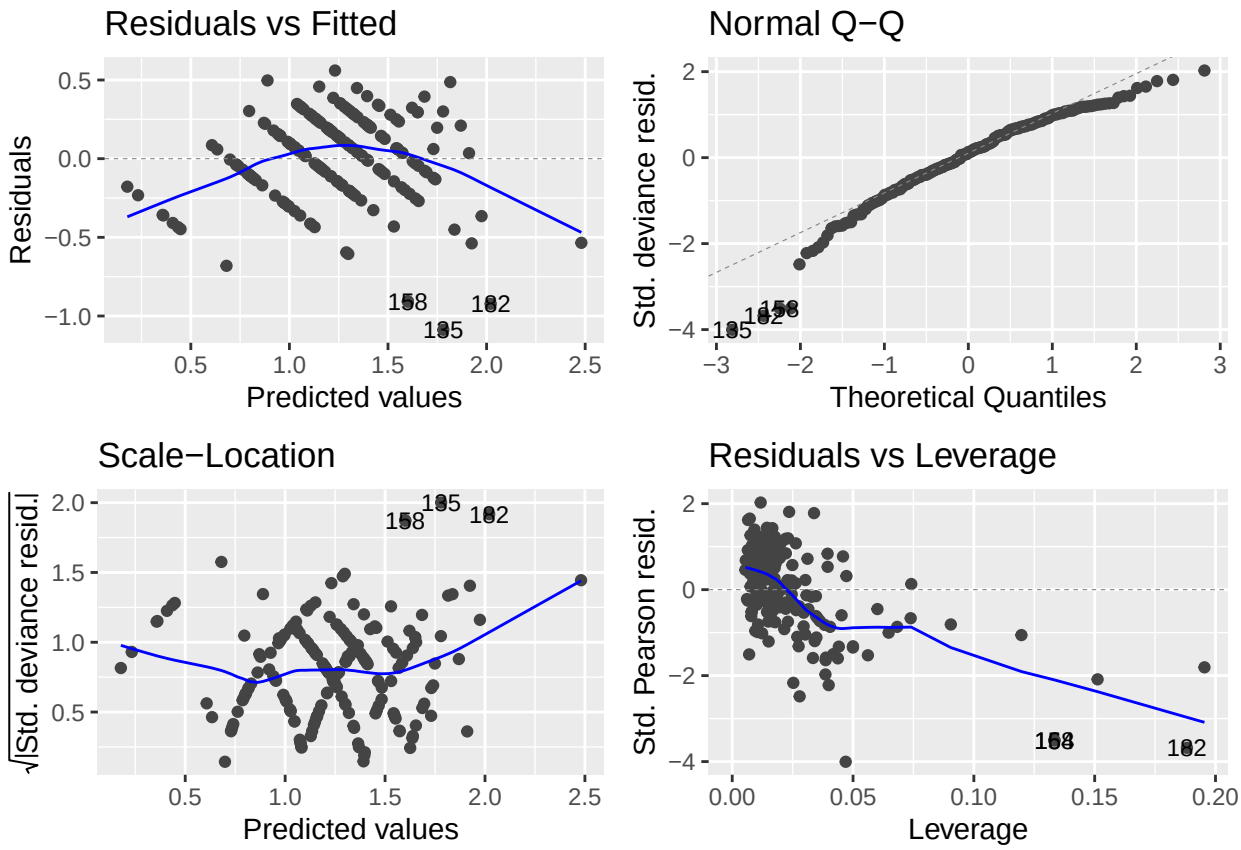
It seems that FCL_long does not fit a gaussian distribution. Then, how about log (FCL_long)? This would be closer to a gaussian distribution.

```
library(tidyverse)
df=mutate(df, log_FCL_long = log(FCL_long))
model3=glm(log_FCL_long~richness+s1+s2+s5, data=df, family = 'gaussian') # gaussian
summary(model3)
```

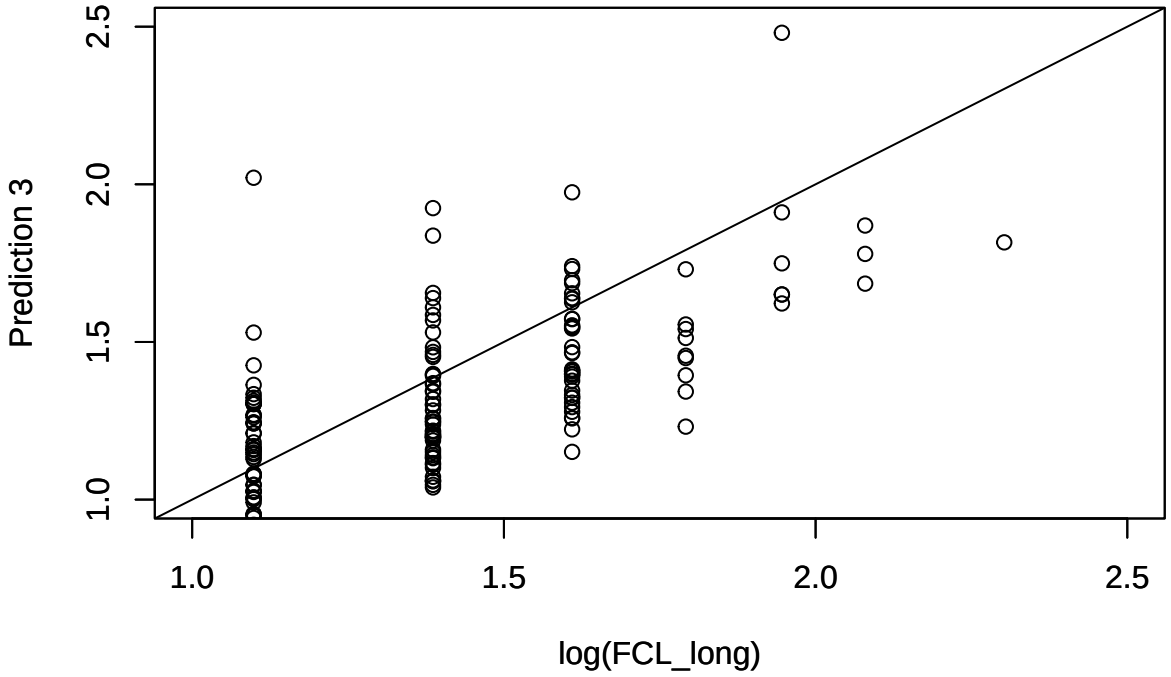
```
##
## Call:
## glm(formula = log_FCL_long ~ richness + s1 + s2 + s5, family = "gaussian",
##     data = df)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -1.08744  -0.14347   0.03492   0.20144   0.56036
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.900445   0.037923  23.744  < 2e-16 ***
## richness     0.018166   0.001762  10.311  < 2e-16 ***
## s1           0.148573   0.026162   5.679 4.78e-08 ***
## s2           0.230307   0.024177   9.526  < 2e-16 ***
## s5          -0.093077   0.028793  -3.233  0.00144 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.07737479)
##
##     Null deviance: 39.049  on 202  degrees of freedom
## Residual deviance: 15.320  on 198  degrees of freedom
##   (10 observations deleted due to missingness)
```

```
## AIC: 63.53
##
## Number of Fisher Scoring iterations: 2
```

```
autoplot(model3, label.size = 3)
```




```
plot(df$log_FCL_long[-(which(is.na(df$log_FCL_long)))],predict(model3),
     xlab='log(FCL_long)', ylab='Prediction 3',
     xlim=c(1,2.5), ylim=c(1, 2.5))
par(new=T)
plot(c(0:3), c(0:3), type='l',
      xlab='log(FCL_long)', ylab='Prediction 3',
     xlim=c(1,2.5), ylim=c(1, 2.5))
```


Prediction 3
1.0
1.5
2.0
2.5
log(FCL_long)