

2023-03-09

```
knitr::opts_knit$set(root.dir = rprojroot::find_rstudio_root_file())
```

```
# === Model - glmm -----

# Packages -----
library(lme4)
library(ggplot2)
library(visreg)
library(data.table)
library(sjstats)
library(performance)

#input data
data=readRDS("output/09-all-dyad-data.Rds")

summary(data)
```

```
##      dyadID          ID1          ID2          Year
## Length:253      Length:253      Length:253      Min.   :2017
## Class :character Class :character Class :character 1st Qu.:2018
## Mode  :character Mode  :character Mode  :character Median :2018
##                                           Mean  :2018
##                                           3rd Qu.:2019
##                                           Max.   :2019
##      sri          udoi      diff_total_length diff_heart_girth
## Min.   :0.00000   Min.   :0.00000   Min.   : 0.000   Min.   : 0.000
## 1st Qu.:0.00000   1st Qu.:0.03096   1st Qu.: 2.000   1st Qu.: 1.500
## Median :0.02927   Median :0.31326   Median : 5.000   Median : 4.000
## Mean   :0.05699   Mean   :0.49570   Mean   : 5.895   Mean   : 4.439
## 3rd Qu.:0.08419   3rd Qu.:0.93161   3rd Qu.: 8.000   3rd Qu.: 6.000
## Max.   :0.32666   Max.   :1.46212   Max.   :26.000   Max.   :14.000
## diff_sum_heart_length
## Min.   : 0.000
## 1st Qu.: 3.500
## Median : 7.500
## Mean   : 8.571
## 3rd Qu.:12.000
## Max.   :38.000
```

```
str(data)
```

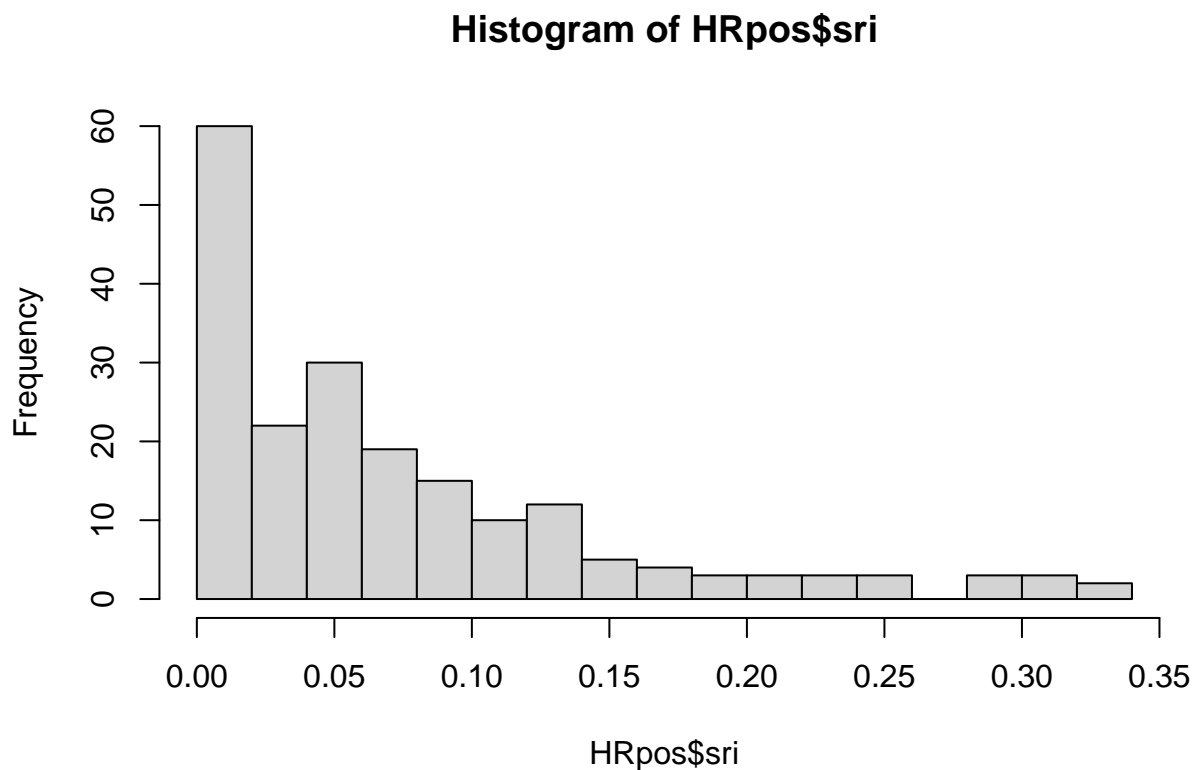
```
## Classes 'data.table' and 'data.frame': 253 obs. of 9 variables:
## $ dyadID      : chr "F02016002-F02016003" "F02016002-F02016004" "F02016002-F02016004" "F02016002-F02016004" ...
## $ ID1         : chr "F02016003" "F02016004" "F02016004" "F02016005" ...
## $ ID2         : chr "F02016002" "F02016002" "F02016002" "F02016002" ...
## $ Year        : int 2017 2017 2018 2017 2018 2019 2017 2019 2017 2018 ...
## $ sri         : num 0.0851 0.1124 0.0821 0.0936 0.1111 ...
## $ udoi        : num 1.253 0.932 0.277 0.577 0.334 ...
## $ diff_total_length : num 11 0.5 0.5 5.5 5.5 5.5 13.5 0 5 5 ...
## $ diff_heart_girth : num 2.5 1 1 4 4 4 9 6 3 3 ...
## $ diff_sum_heart_length: num 8.5 0.5 0.5 9.5 9.5 9.5 22.5 6 8 8 ...
```

```
## - attr(*, "sorted")= chr [1:3] "dyadID" "ID1" "ID2"
## - attr(*, ".internal.selfref")=<externalptr>

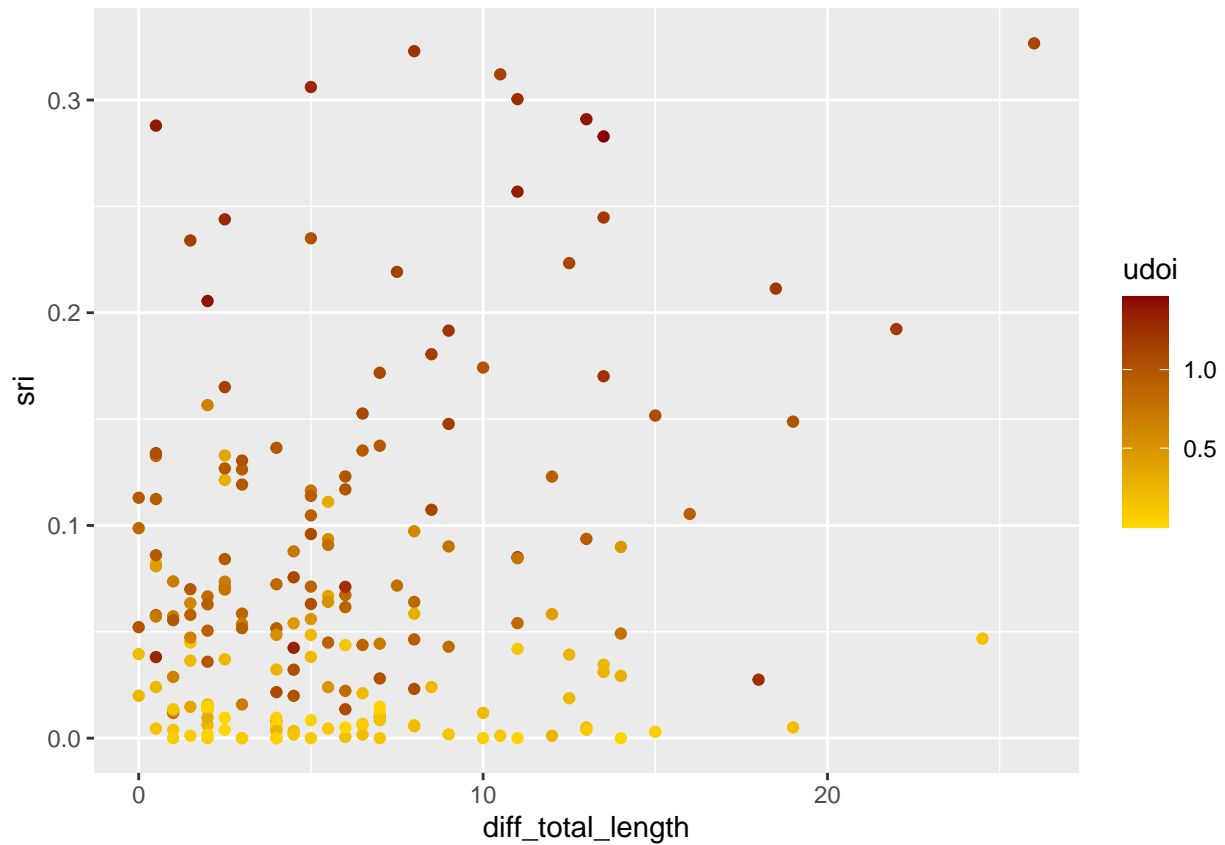
# Does caribou associate according to size similarity? -----
# Expected = SRI is higher when diff in body size is small

# We work with caribou in the same HR (udo_i>0)
HRpos=subset(data,udo_i>0)
HRpos[, Difference:= diff_total_length]

# Data exploration
hist(HRpos$sri, breaks = 20)
```



```
plot2=ggplot(HRpos,aes(x=diff_total_length,y=sri, color=udo_i))+geom_point()
plot2+scale_color_gradient(low="gold", high="dark red")
```



```
# GLMMs -----

# with diff in (heart girth + total length)

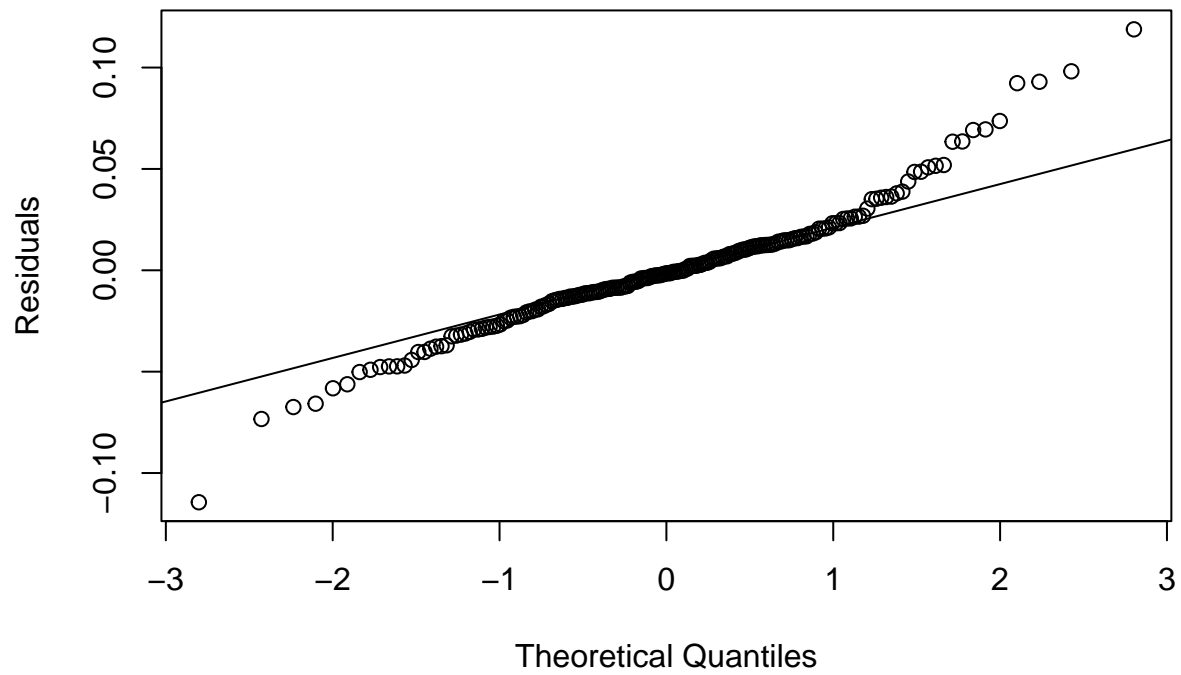
mod1=lmer(sri~Difference *udo + Difference+udo+(1|dyadID)+(1|Year), data=HRpos)

mod1.1=lmer(log(sri+1)~Difference*udo + Difference+udo+(1|dyadID)+(1|Year), data=HRpos) # with log

mod1.2=lmer(sqrt(sri)~udo*Difference+udo+ Difference +(1|dyadID)+(1|Year), data=HRpos) # with sqrt

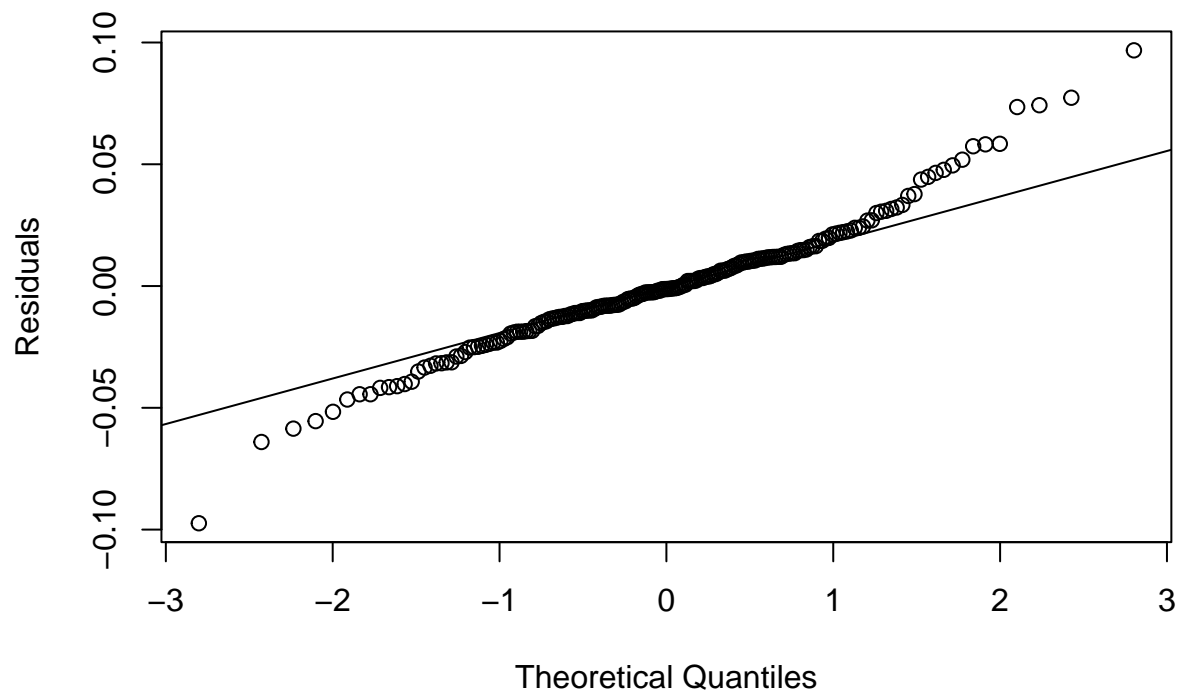
# par(mfrow=c(1,3))
qqnorm(residuals(mod1),ylab="Residuals")      #ko
qqline(residuals(mod1))
```

Normal Q-Q Plot



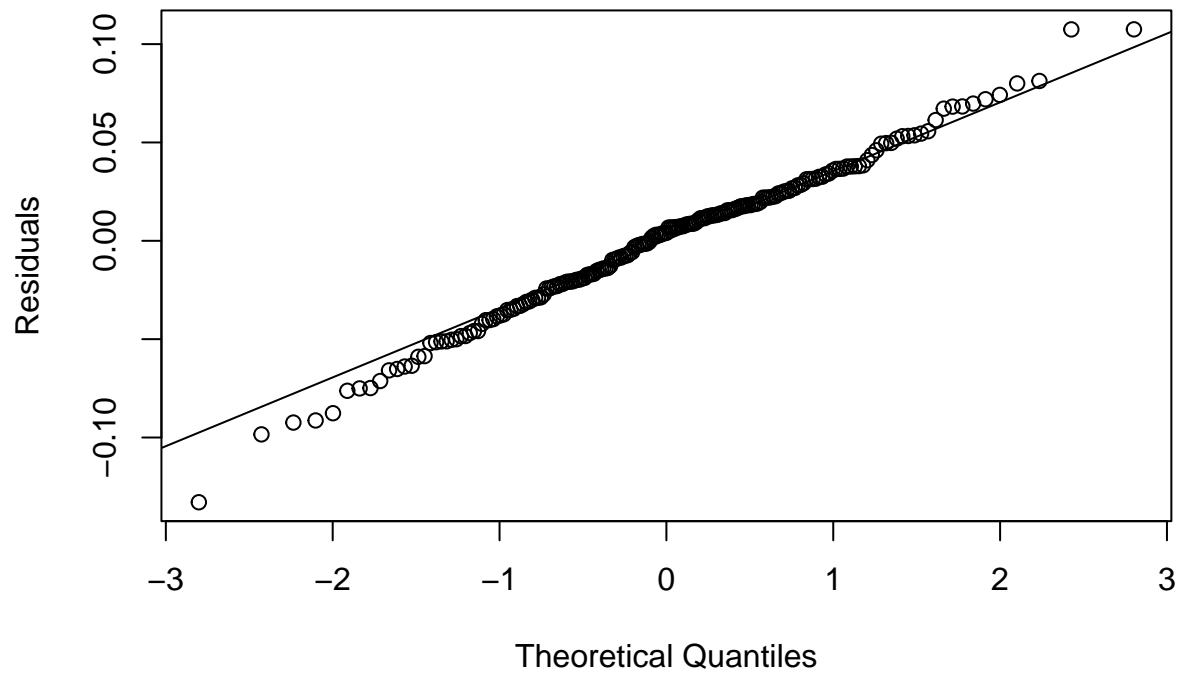
```
qqnorm(residuals(mod1.1),ylab="Residuals")    #ko  
qqline(residuals(mod1.1))
```

Normal Q-Q Plot

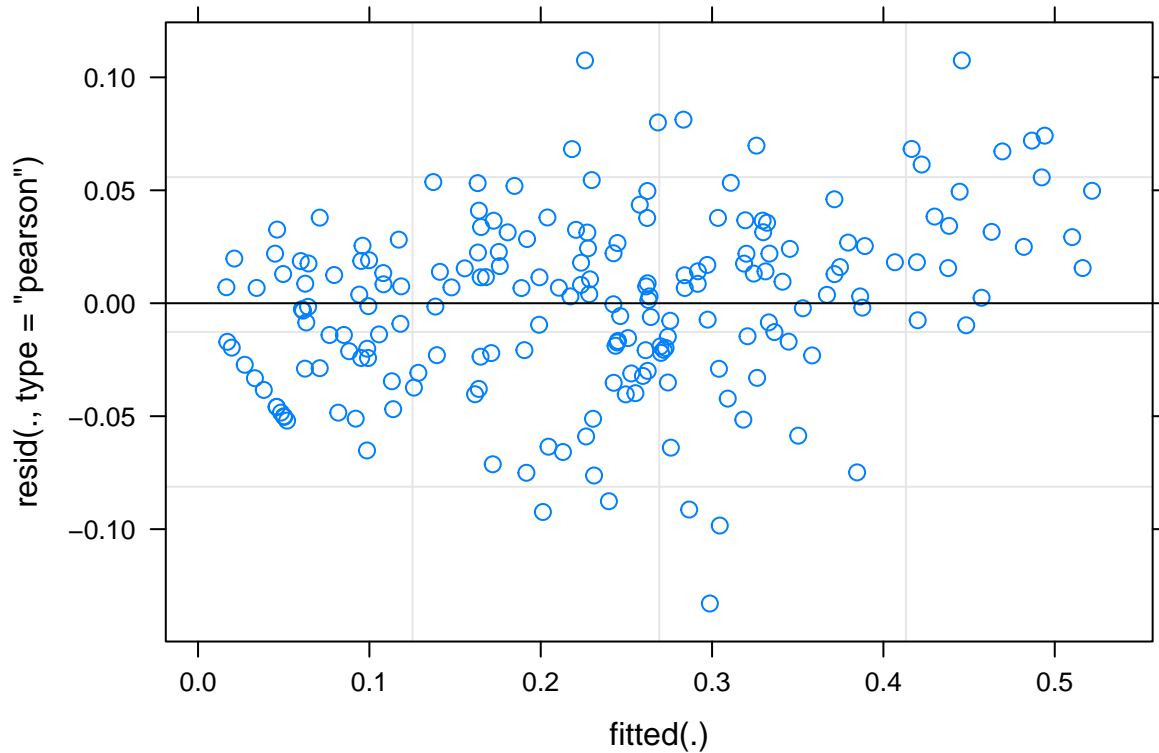


```
qqnorm(residuals(mod1.2),ylab="Residuals")    #ok  
qqline(residuals(mod1.2))
```

Normal Q-Q Plot



```
# par()  
plot(mod1.2)    #homoscedasticity ok
```



```
shapiro.test((residuals(mod1.2)))

##
##  Shapiro-Wilk normality test
##
## data:  (residuals(mod1.2))
## W = 0.99209, p-value = 0.3635

# p-value
Vcov <- vcov(mod1.2, useScale = FALSE)
betas <- fixef(mod1.2)
se <- sqrt(diag(Vcov))
zval <- betas / se
pval <- 2 * pnorm(abs(zval), lower.tail = FALSE)
round(cbind(betas, se, zval, pval), digits = 3)

##          betas    se   zval  pval
## (Intercept)  0.096 0.022  4.333 0.000
## udoi         0.199 0.020  9.815 0.000
## Difference   -0.003 0.002 -1.446 0.148
## udoi:Difference 0.007 0.003  2.855 0.004

#          betas    se   zval  pval
# #Intercept)  0.096 0.022  4.333 0.000
# #udo         0.199 0.020  9.815 0.000
# #Difference   -0.003 0.002 -1.446 0.148
# #udoi:Difference 0.007 0.003  2.855 0.004
```

```

r2(mod1.2)

## # R2 for Mixed Models
##
##   Conditional R2: 0.844
##   Marginal R2: 0.610
#Conditional R2: 0.844
#Marginal R2: 0.610

# ==> Caribou associate more often when HR overlap is bigger and big difference in size

# Plots of the fixed effects -----

#Backtransformation of the sqrt of the response
square <- function(x){
  return(x**2)
}

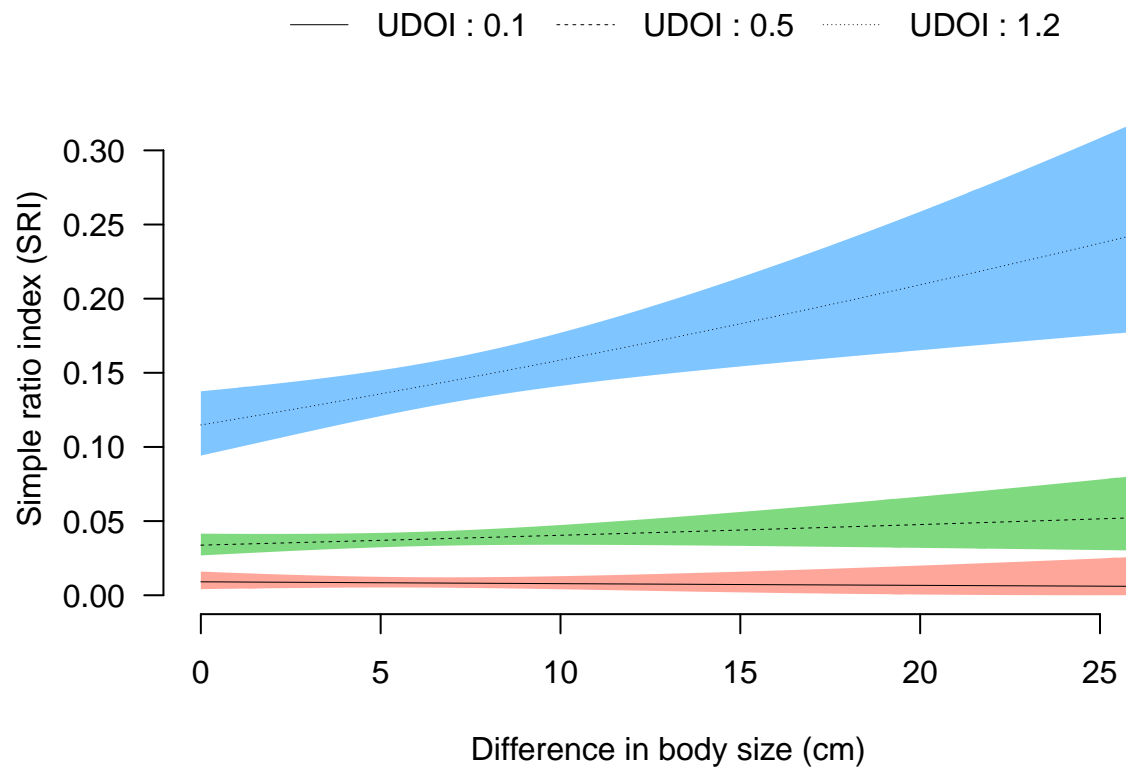
# random effect removed for plot, otherwise, no CI on the graph

HRpos$UDOI=HRpos$udoi
mod1.A=lm(sqrt(sri)~Difference*UDOI, data=HRpos)
# dev.off()
visreg(mod1.A,"Difference", by="UDOI",

       breaks = c(0.1, 0.5, 1.2),

       trans=square,xlab="Difference in body size (cm)",
       ylab="Simple ratio index (SRI)", overlay = TRUE, partial = FALSE, rug=FALSE, frame.plot=FALSE,leg
       line=list(lty=1:3, col="black", lwd=0.5))

```

```
# -----
mod1

## Linear mixed model fit by REML ['lmerMod']
## Formula: sri ~ Difference * udoi + Difference + udoi + (1 | dyadID) +
##      (1 | Year)
## Data: HRpos
## REML criterion at convergence: -592.9123
## Random effects:
## Groups   Name                Std.Dev.
## dyadID   (Intercept) 0.03109
## Year     (Intercept) 0.01391
## Residual                    0.03841
## Number of obs: 197, groups: dyadID, 155; Year, 3
## Fixed Effects:
##      (Intercept)      Difference          udoi  Difference:udo
##      0.007752      -0.001899      0.084265      0.005678

mod1.1

## Linear mixed model fit by REML ['lmerMod']
## Formula: log(sri + 1) ~ Difference * udoi + Difference + udoi + (1 | dyadID) +
##      (1 | Year)
## Data: HRpos
## REML criterion at convergence: -644.8071
## Random effects:
## Groups   Name                Std.Dev.
```

```

## dyadID (Intercept) 0.02802
## Year (Intercept) 0.01245
## Residual 0.03300
## Number of obs: 197, groups: dyadID, 155; Year, 3
## Fixed Effects:
## (Intercept) Difference udoi Difference:udo
## 0.008994 -0.001683 0.077859 0.004870

```

mod1.2

```

## Linear mixed model fit by REML ['lmerMod']
## Formula: sqrt(sri) ~ udoi * Difference + udoi + Difference + (1 | dyadID) +
## (1 | Year)
## Data: HRpos
## REML criterion at convergence: -402.242
## Random effects:
## Groups Name Std.Dev.
## dyadID (Intercept) 0.06233
## Year (Intercept) 0.02395
## Residual 0.05457
## Number of obs: 197, groups: dyadID, 155; Year, 3
## Fixed Effects:
## (Intercept) udoi Difference udoi:Difference
## 0.096127 0.198669 -0.003281 0.007336

```