# Spatial orientation of social caterpillars is influenced by polarised light

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**Rcodes used for *Statistical analyses* from Uemura *et al.***

## The Wallraff Test of Angular Distances

```
See http://cran.wustl.edu/web/packages/circular/circular.pdf for
full information
## WALLRAFF TEST TO COMPARE 2 GROUPS ##
# TREGNAGO L1 larvae PF HORIZONTAL FIRST & SECOND EXPOSURE

install.packages('circular')
library(circular)
data1 <- list(
PF.First = circular(c(90, 90, 90, 90, 90, 90, 90),
units="degrees", template="geographics"),
PF.Second = circular(c(90, 90, 90, 90, 90, 90, 180),
units="degrees", template="geographics")
)
# compare the angular dispersion between the two groups
wallraff.test(data1)


# predicted angular difference is 90 degrees for both groups
wallraff.test(data1,
ref = circular(c(90, 90), units="degrees",
template="geographics")
```

## Circular Logistics Regression Model (CLRM) for Binomial Data

```
## CLRM FOR BINOMIAL DATA ##
# TREGNAGO L1 larvae
library(circular)


# Check for correlation between numeric variables
dat <- read.csv()
dat$Azimuth <- as.numeric(dat$Azimuth)
dat$Temp <- as.numeric(dat$Temp)
dat$N <- as.numeric(dat$N)
dat$StartOrientation <- as.numeric(dat$StartOrientation)
dat$Angular.dif <- as.integer(dat$Angular.dif)


x <- cbind(dat$Azimuth, dat$Temp, dat$N, dat$StartOrientation)
cor(x, method = "pearson", use = "complete.obs") # check correlation
r > 0.7 remove


# Circular Logistics Regression Model (Al-Daffaie & Khan 2017)
GLMFull <- glm(Angular.dif ~ cos(Azimuth) + sin(Azimuth) + Treatment
+ ID + N + cos(StartOrientation) + sin(StartOrientation), data =
dat, family = binomial(link = "logit"))
summary(GLMFull)


GLMRed <- glm(Angular.dif ~ Treatment, data = dat, family =
binomial(link = "logit"))
summary(GLMRed)
```

## Circular histogram (rose diagram)

The angular difference for each treatment and group (L1 and L5 *T. pityocampa* and L8 *O. lunifer*) were plotted as a circular histogram using the package 'ggplot2' (Wickham 2016). For each circular histogram, a Kuiper's Test of Uniformity was used from the package 'circular' to determine if the angular difference was random or not (Agostinelli and Lund 2017).

```
## CIRCULAR HISTOGRAM FOR TREATMENT AND GROUP ##
library(ggplot2)
dat <- read.csv()
PF1 <- as.numeric(dat$PF1)
meanPF1 <- mean(PF1)

rose <- ggplot(mapping = aes(x = PF1)) + theme(panel.background =
element_blank(), axis.title.x=element_blank(),
axis.title.y=element_blank(), axis.text.x =
element_text(color="black", size = 18, face = "bold"), axis.text.y =
element_text(color="black", size = 16),
panel.grid.major = element_line(colour="grey65"), panel.grid.minor =
element_line(colour="grey65")) +
geom_histogram(colour="black", size = 0.5, fill = "darkgrey",
center=0, breaks = (0:20 - 0.5)/20 * 360) +
scale_x_continuous(breaks = 0:7/8*360, labels = c("0", "45", "90",
"135", "180", "225", "270", "315")) + coord_polar(start=-pi/20)
rose


L1PF1 <- rose + geom_vline(xintercept = meanPF1,linetype = 2, color
= "black", size = 1)
L1PF1
ggsave(L1PF1, filename = "Treg_PF1.wmf", path = "", width = 4,
height = 6, units = "in", dpi = 300)
```

## Circular histogram with kernel density estimate

Summarised angular difference of each treatment and group were represented graphically as a circular plot with a kernel density estimation (Fig. 1). See (Charpentier, 2011) for details.

```
#### CIRCULAR HISTOGRAM + KERNEL DENSITY ESTIMATE ####
library(circular)
dat <- read.csv()
PF1 <- as.numeric(dat$PF1)
PF2 <- as.numeric(dat$PF2)
REM <- as.numeric(dat$REM)
NDF <- as.numeric(dat$NDF)
Blank <- as.numeric(dat$Blank)
meanNDF <- mean(NDF)

Ht1 <- circular(PF1,type="angles", units = "degrees", template =
"geographics")
circ.densPF1 = density(Ht1+3*pi/2,bw=20)
Ht2 <- circular(PF2,type="angles", units = "degrees", template =
"geographics")
circ.densPF2 = density(Ht2+3*pi/2,bw=20)
Ht3 <- circular(REM,type="angles", units = "degrees", template =
"geographics")
circ.densREM = density(Ht3+3*pi/2,bw=20)
Ht4 <- circular(NDF,type="angles", units = "degrees", template =
"geographics")
circ.densNDF = density(Ht4+3*pi/2,bw=20)

NDF <- circular(NDF, type="angles",units="degrees",
rotation="clock", zero=pi/2)
plot(Blank, cex=1.1, bin=720, stack=TRUE, sep=0.035, shrink=3.5,
tcl.text=.2, main="Ochrogaster lunifer L8", font.main=2)
rose.diag(NDF, cex=1.1, col = "darkgray", bin=20, stack=TRUE,
sep=0.035, shrink=2.5, prop = 0.7, tcl.text=0.2, main="Ochrogaster
lunifer L8", font.main=2)
ticks.circular(circular(seq(0,2*pi,pi/8)), zero=pi/2,
rotation='clock', tcl=0.075)
lines(circ.densPF1, col="black", lty=2, lwd=2) + lines(circ.densPF2,
col="black", lty = 3, lwd=4)
lines(circ.densREM, col="darkgray", lty = 4, lwd=3) +
lines(circ.densNDF, col="darkgray", lty = 1, lwd=2)
arrows.circular(mean(NDF,na.rm=TRUE),angle=15,length=0.06,lty = 1,
lwd=1,col="red")
legend("topleft", bg="transparent", legend=c("PF horizontal", "PF
vertical", "PF removal", "NDF"), col=c("black", "black", "darkgray",
"darkgray"), lty= c(2,3,4,1), cex=1, box.lty=0, lwd = c(3,3,3,3))
```

## References

Agostinelli C, Lund U. 2017 R package 'circular': Circular Statistics (version 0.4-93). See https://r-forge.r-project.org/projects/circular/.

Al-Daffaie K, Khan S. 2017 Logistic regression for circular data. In AIP Conference Proceedings, p. 8. (doi:10.1063/1.4982860)

Charpentier, A. 2011 Circular or spherical data, and density estimation. Freakonomics. See https://freakonometrics.hypotheses.org/tag/spherical (accessed on 4 December 2020).

Wickham H. 2016 ggplot2: Elegant graphics for data analysis. 2nd edn. New York: Springer International Publishing. (doi:10.1007/978-3-319-24277-4)