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##############################################################################
##########  Agama lizard habitat use and selection in Homestead, FL ##########
##########       -- B Folt, March 20202 --                          ##########
##############################################################################

# Clear the workspace
rm(list=ls())

# Set the working directory
setwd("C:/Users/bfolt/OneDrive - DOI/Desktop/Research/Agama site occupancy/R")

# Load the data file
datum = read.csv("Agama-sites.csv", header = TRUE)
head(datum)

# remove all sites that we were unable to sample
datum = droplevels(subset(datum, datum$Agama != "NA"))


### Basic graphs describing Agama abundance in Core vs. Peripheral random
sites
plot(factor(datum$Core), datum$Agama,
ylab=expression(Number~of~italic(Agama~picticauda)))
stripchart(Agama~Core, data=datum, vertical=TRUE, pch=1, method="jitter",
add=TRUE)
res = lm(datum$Agama ~ datum$Core)
summary(res)


####### Part 1 --
####### Habitat correlates with abundance
####### I.e.,

### Number of Agama as a result of various structures
### Use multi-model inference to evaluate how habitat attributes
### predict abundance of Agama picticauda in south Florida
library(MuMIn) # Dredge and model average functions
library(lme4)
options(na.action = "na.fail")

# All factors in model structure
model = glm(Agama ~ Crevices + Dumpsters + Electrical.units +
               Trees + AC.Units + Vertical.structures,
             data=datum, na.action="na.fail")
dd = dredge(model)

# Report these results in manuscript
head(dd)
confset.95p <- get.models(dd, subset=TRUE)
modavg <- model.avg(confset.95p, revised.var=TRUE)
summary(modavg)
confint(modavg, level=0.95)
  # confidence intervals for crevices, dumpsters, electrical units
  # do not overlap zero.
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  # trees doesn't either, but it's misbehaving; excluded


#### E.g.,
#### Make nice graphs for the significant results

# Crevices
plot(datum$Crevices, datum$Agama, axes=FALSE, lwd=4, lty=1, type="n",
     xlab="Number of crevices", cex.lab=1.2, cex.axis=1.5,
     ylab=expression(Number~of~italic(Agama~picticauda)))
axis(1, c(0,1,2,3), lwd=4.5, cex.axis=1.3)
axis(2, c(0,1,2,3,4,5,6), lwd=4.5, cex.axis=1.3)
points(jitter(datum$Crevices), datum$Agama, cex=1, pch=21, bg=8, col=1)
res = lm(datum$Agama ~ datum$Crevices, data=datum)
summary(res)
abline(res, lwd=3)
text(2.6,0.5, "P < 0.001", font=1, cex=1.5, col=9)


#### Stack graphs showing simple linear regression from
#### significant effects recovered in multi-model inference
dev.off()
par(mfrow=c(3,1), oma=c(5,4,0,0)+0.5, mar=c(1,1,3,1)+0.5)

# Dumpsters
plot(datum$Dumpsters, datum$Agama, lwd=2, axes=FALSE, type="n",
     cex.lab=1.4, cex.axis=2, ylab="No. of Agama", xlab="No. of dumpsters")
dumps = lm(Agama ~ Dumpsters, data=datum)
wx = par("usr")[1:2]
new.x = seq(wx[1],wx[2],len=100)
pred = predict(dumps, new=data.frame(Dumpsters=new.x), interval="conf")
lines(new.x, pred[,"fit"],lwd=2); lines(new.x, pred[,"lwr"],lty=3);
lines(new.x, pred[,"upr"],lty=3)
points(jitter(subset(datum, datum$Core == "Core")$Dumpsters, factor=1.2),
subset(datum, datum$Core == "Core")$Agama, pch=21, cex=1.5, bg=8, col=1)
points(jitter(subset(datum, datum$Core == "Periphery")$Dumpsters, factor=1.2),
subset(datum, datum$Core == "Periphery")$Agama, pch=23, cex=1.5, bg=8, col=1)
axis(1, c(0,1,2,3,4,5), lwd=4, cex.axis=1.7)
axis(2, c(0,1,2,3,4,5,6), lwd=4, cex.axis=1.7)
#mtext("Number of dumpsters", side=1, line=3, cex=1.2, col="black")
text(0.3,5.5,"A", cex=3)
#text(4.28,2.25, "P < 0.05", font=1, cex=1.6, col=9)
legend(3.67, 1.8, inset=0.05, legend=c("Focal","Random"),
       pch=c(21,23), pt.bg=c(8,8), col=1, cex=1.2, box.lwd=1.5, pt.lwd=1)

# Crevices
plot(datum$Crevices, datum$Agama, lwd=2, axes=FALSE, type="n",
     cex.lab=1.4, cex.axis=2, ylab="No. of Agama", xlab="No. of crevices")
crevices = lm(Agama ~ Crevices, data=datum)
wx = par("usr")[1:2]
new.x = seq(wx[1],wx[2],len=100)
pred = predict(crevices, new=data.frame(Crevices=new.x), interval="conf")
lines(new.x,pred[,"fit"],lwd=2); lines(new.x,pred[,"lwr"],lty=3);
lines(new.x,pred[,"upr"],lty=3)
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points(jitter(subset(datum, datum$Core == "Core")$Crevices, factor=1.2),
subset(datum, datum$Core == "Core")$Agama, pch=21, cex=1.5, bg=8, col=1)
points(jitter(subset(datum, datum$Core == "Periphery")$Crevices, factor=1.2),
subset(datum, datum$Core == "Periphery")$Agama, pch=23, cex=1.5, bg=8, col=1)
axis(1, c(0,1,2,3), lwd=4, cex.axis=1.7)
axis(2, c(0,1,2,3,4,5,6), lwd=4, cex.axis=1.7)
mtext("Number of crevices", side=1, line=3, cex=1.2, col="black")
text(0.18,5.5,"B", cex=3)
#text(2.6,0.5, "P < 0.001", font=1, cex=1.6, col=9)
mtext(expression(Observed~abundance~of~italic(Agama~picticauda)), side=2,
line=3, cex=1.2, col="black")

# Electrical units
plot(datum$Electrical.units, datum$Agama, lwd=2, axes=FALSE, type="n",
     cex.lab=1.4, cex.axis=2, ylab="No. of Agama", xlab="No. of electrical
units")
crevices = lm(Agama ~ Electrical.units, data=datum)
wx = par("usr")[1:2]
new.x = seq(wx[1],wx[2],len=100)
pred = predict(crevices, new=data.frame(Electrical.units=new.x),
interval="conf")
lines(new.x,pred[,"fit"],lwd=2); lines(new.x,pred[,"lwr"],lty=3);
lines(new.x,pred[,"upr"],lty=3)
points(jitter(subset(datum, datum$Core == "Core")$Electrical.units,
factor=1.2), subset(datum, datum$Core == "Core")$Agama, pch=21, cex=1.5, bg=8,
col=1)
points(jitter(subset(datum, datum$Core == "Periphery")$Electrical.units,
factor=1.2), subset(datum, datum$Core == "Periphery")$Agama, pch=23, cex=1.5,
bg=8, col=1)
axis(1, c(0,1,2,3), lwd=4, cex.axis=1.7)
axis(2, c(0,1,2,3,4,5,6), lwd=4, cex.axis=1.7)
mtext("Number of electrical units", side=1, line=3, cex=1.2, col="black")
text(0.18,5.5,"c", cex=3)
#text(2.6,0.5, "P = 0.021", font=1, cex=1.6, col=9)


#### Stack graphs showing linear relationships of habitat effects
#### on Agama abundance inferred from a fully-average model resulting from
#### multi-model inference
dev.off()
par(mfrow=c(3,1), oma=c(5,4,0,0)+0.5, mar=c(1,1,3,1)+0.5)

# Dumpsters
plot(datum$Dumpsters, datum$Agama, lwd=2, axes=FALSE, type="n",
     cex.lab=1.4, cex.axis=2, ylab="No. of Agama", xlab="No. of dumpsters")
nseq <- function(x, len = length(x)) seq(min(x, na.rm = TRUE), max(x,
na.rm=TRUE), length = len)
newdata <- as.data.frame(lapply(lapply(datum[,c("Dumpsters", "Crevices",
"Electrical.units", "Trees", "AC.Units", "Vertical.structures")], mean), rep,
25))
newdata$Dumpsters <- nseq(datum$Dumpsters, nrow(newdata))
n <- length(confset.95p)
pred <- data.frame(model = sapply(confset.95p, predict, newdata=newdata),
averaged.full = predict(modavg, newdata, full = TRUE))
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pred.se <- predict(modavg, newdata, se.fit = TRUE)
y <- pred.se$fit
ci <- pred.se$se.fit  * 2
matplot(newdata$Dumpsters, cbind(y, y - ci, y + ci), add = TRUE, type="l", lty
= c(1,3,3), col = "black", lwd = c(2,1,1))
points(jitter(subset(datum, datum$Core == "Core")$Dumpsters, factor=1.2),
subset(datum, datum$Core == "Core")$Agama, pch=21, cex=1.5, col="black",
bg="grey")
points(jitter(subset(datum, datum$Core == "Periphery")$Dumpsters, factor=1.2),
subset(datum, datum$Core == "Periphery")$Agama, pch=23, cex=1.5, col="black",
bg="grey")
axis(1, c(0,1,2,3,4,5), lwd=4, cex.axis=1.7)
axis(2, c(0,1,2,3,4,5,6), lwd=4, cex.axis=1.7)
#mtext("Number of dumpsters", side=1, line=3, cex=1.2, col="black")
text(0.3,5.5,"A", cex=3)
#text(4.28,2.25, "P < 0.05", font=1, cex=1.6, col=9)
legend(3.67, 1.8, inset=0.05, legend=c("Focal","Random"),
       pch=c(21,23), pt.bg=c("grey","grey"), col="black", cex=1.2,
box.lwd=1.5, pt.lwd=1)

# Crevices
plot(datum$Crevices, datum$Agama, lwd=2, axes=FALSE, type="n",
     cex.lab=1.4, cex.axis=2, ylab="No. of Agama", xlab="No. of crevices")
nseq <- function(x, len = length(x)) seq(min(x, na.rm = TRUE), max(x,
na.rm=TRUE), length = len)
newdata <- as.data.frame(lapply(lapply(datum[,c("Dumpsters", "Crevices",
"Electrical.units", "Trees", "AC.Units", "Vertical.structures")], mean), rep,
25))
newdata$Crevices <- nseq(datum$Crevices, nrow(newdata))
n <- length(confset.95p)
pred <- data.frame(model = sapply(confset.95p, predict, newdata=newdata),
averaged.full = predict(modavg, newdata, full = TRUE))
pred.se <- predict(modavg, newdata, se.fit = TRUE)
y <- pred.se$fit
ci <- pred.se$se.fit  * 2
matplot(newdata$Crevices, cbind(y, y - ci, y + ci), add = TRUE, type="l", lty
= c(1,3,3), col = "black", lwd = c(2,1,1))
points(jitter(subset(datum, datum$Core == "Core")$Crevices, factor=1.2),
subset(datum, datum$Core == "Core")$Agama, pch=21, cex=1.5, col="black",
bg="grey")
points(jitter(subset(datum, datum$Core == "Periphery")$Crevices, factor=1.2),
subset(datum, datum$Core == "Periphery")$Agama, pch=23, cex=1.5, col="black",
bg="grey")
axis(1, c(0,1,2,3), lwd=4, cex.axis=1.7)
axis(2, c(0,1,2,3,4,5,6), lwd=4, cex.axis=1.7)
mtext("Number of crevices", side=1, line=3, cex=1.2, col="black")
text(0.18,5.5,"B", cex=3)
#text(2.6,0.5, "P < 0.001", font=1, cex=1.6, col=9)
mtext(expression(Observed~abundance~of~italic(Agama~picticauda)), side=2,
line=3, cex=1.2, col="black")

# Electrical units
plot(datum$Electrical.units, datum$Agama, lwd=2, axes=FALSE, type="n",
```

```
     cex.lab=1.4, cex.axis=2, ylab="No. of Agama", xlab="No. of electrical
units")
nseq <- function(x, len = length(x)) seq(min(x, na.rm = TRUE), max(x,
na.rm=TRUE), length = len)
newdata <- as.data.frame(lapply(lapply(datum[,c("Dumpsters", "Crevices",
"Electrical.units", "Trees", "AC.Units", "Vertical.structures")], mean), rep,
25))
newdata$Electrical.units <- nseq(datum$Electrical.units, nrow(newdata))
n <- length(confset.95p)
pred <- data.frame(model = sapply(confset.95p, predict, newdata=newdata),
averaged.full = predict(modavg, newdata, full = TRUE))
pred.se <- predict(modavg, newdata, se.fit = TRUE)
y <- pred.se$fit
ci <- pred.se$se.fit  * 2
matplot(newdata$Electrical.units, cbind(y, y - ci, y + ci), add = TRUE,
type="l", lty = c(1,3,3), col = "black", lwd = c(2,1,1))
points(jitter(subset(datum, datum$Core == "Core")$Electrical.units,
factor=1.2), subset(datum, datum$Core == "Core")$Agama, pch=21, cex=1.5,
col="black", bg="grey")
points(jitter(subset(datum, datum$Core == "Periphery")$Electrical.units,
factor=1.2), subset(datum, datum$Core == "Periphery")$Agama, pch=23, cex=1.5,
col="black", bg="grey")
axis(1, c(0,1,2,3), lwd=4, cex.axis=1.7)
axis(2, c(0,1,2,3,4,5,6), lwd=4, cex.axis=1.7)
mtext("Number of electrical units", side=1, line=3, cex=1.2, col="black")
text(0.18,5.5,"C", cex=3)
#text(2.6,0.5, "P = 0.021", font=1, cex=1.6, col=9)



####### Part 2 --
####### Second-order habitat selection; selection for sites
dev.off()
options(scipen=999)
head(datum)

# Create a vector of Agama presence/absence
Presence = datum$Agama
for (i in 1:length(Presence)){
  if(Presence[i] != 0){Presence[i] = 1}}
datum2 = cbind(Presence, datum)#, datum$Site)
#colnames(datum2)[9] = "Site"

# Analyze Agama presence/absence as it relates to habitat covariates
# with an all-subsets analysis
model = glm(Presence ~ Dumpsters + Electrical.units + Trees +
Vertical.structures,
            data=datum, family=binomial, na.action="na.fail")
summary(model)


# All-subsets analysis
dd = dredge(model)
```

```
# Report these results in manuscript
head(dd)
modavg = model.avg(dd)
summary(modavg)
confint(modavg, level=0.95)
  # electrical unit does not overlap zero

exp(modavg$coefficients) # <- probality effect sizes among groups
exp(confint(modavg))




####### Part 3 --
####### Third-order habitat selection:
####### Microhabitat use vs. available
dev.off()

datum = read.csv("Agama-structures.csv",header=TRUE)
head(datum)

# Subset the dataframe to the structures with most data
summary(datum$Structure2)
  # Fence, Guard rail, Rock, Tire pile, Utility pole, Wall stucture
  # all have 5 or fewer observations; subset and remove to decrease DF
datum = droplevels(subset(datum, datum$Structure2 != "Fence"))
datum = droplevels(subset(datum, datum$Structure2 != "Guard rail"))
datum = droplevels(subset(datum, datum$Structure2 != "Rock"))
datum = droplevels(subset(datum, datum$Structure2 != "Tire pile"))
datum = droplevels(subset(datum, datum$Structure2 != "Utility pole"))
datum = droplevels(subset(datum, datum$Structure2 != "Wall structure"))
summary(datum$Structure2)
  # Now just seven use/non-use categories

#### Use vs. availability assessment
#### Do Agama use certain structures proportionally greater than
#### the structures are available?

# Analyze Agama presence/absence as it relates to microhabitat use/avoidance
# with an all-subsets analysis
model = glm(Used ~ Bush + Crevice + Dumpster + CementStructure + Tree,
              data=datum, family=binomial, maxit=100)
summary(model)

# All-subsets analysis
dd = dredge(model)

# Results for manuscript
head(dd)
modavg = model.avg(dd)
head(modavg$msTable, 10)
summary(modavg)
confint(modavg)
```

```
  # Bush, recive, and dumpster do not overlap zero

exp(summary(modavg)$coefficients)
exp(confint(modavg))
```