##### REQUIRED PACKAGES FOR ANALYSIS #####

library(tidyverse)

library(lattice)

library(lme4);library(Hmisc);library(boot);library(reshape2); library(car);

library(ggplot2)

library(pscl)

library(glmmTMB)

library(MASS)

library(readr)

library(readxl)

### Data exploration ###

library(DHARMa)

sim.res <- simulateResiduals(model1, n = 1500, plot = T, quantreg=T)

plot(sim.res)

### Test for zero inflation ###

testZeroInflation(model1)

**### Experiment 1: Upper developmental lethal thermal limits ###**

Experiment1 <- read\_csv("./Experiment1.csv",

col\_names=TRUE,

na='NA')

### Egg viability lethal limit ###

Model1 <- drm(eggs\_survived/eggs\_tested~temperature, weights = eggs\_tested, data = Experiment1, fct = LL.3())

ED(Model1, c(50), interval="delta")

### Larval viability lethal limit ###

Model2 <- drm(larvae\_survived/larvae\_tested~temperature, weights = larvae\_tested, data = Experiment1, fct = LL.3())

ED(Model2, c(50), interval="delta")

### Pupal viability lethal limit ###

Model3 <- drm(pupae\_survived/pupae\_tested~temperature, weights = pupae\_tested, data = Experiment1, fct = LL.3())

ED(Model3, c(50), interval="delta")

**### Experiment 2: Effects of elevated developmental temperatures on CTmax ###**

Experiment2 <- read\_csv("./Experiment2.csv",

col\_names=TRUE,

na='NA')

model1<- glm(ctmax ~ sex\*temperature, data = Experiment2)

Anova(model1, type = 2, test.statistic=c("F"))

**### Experiment 3: Effects of elevated developmental temperatures on fertility ###**

Experiment3 <- read\_csv("./Experiment3.csv",

col\_names=TRUE,

na='NA')

### Fecundity ###

Model1<- glm(eggs ~ temperature, data = Experiment3)

Anova(Model1, type = 3, test.statistic=c("F"))

### Egg hatch proportion ###

Model2<- glm(hatch\_proportion ~ temperature, data = Experiment3)

Anova(Model2, type = 3, test.statistic=c("F"))

### Total offspring ###

Model3<- glm(total\_offspring ~ temperature, data = Experiment3)

Anova(Model3, type = 3, test.statistic=c("F"))

**### Experiment 4: Sex-specific effects of elevated developmental temperatures on reproductive success and fertility ###**

Experiment4 <- read\_csv("./Experiment4.csv",

col\_names=TRUE,

na='NA')

### Proportion laying eggs ###

Model1<- glm(Eggs\_zeros ~ female\_temperature\* male\_temperature, family = binomial(link = "logit"), data = Experiment4)

Anova(Model1, type = 3)

### Proportion with viable eggs ###

Model2<- glm(Hatch\_zeros ~ female\_temperature\* male\_temperature, family = binomial(link = "logit"), data = Experiment4)

Anova(Model2, type = 3)

### Proportion with viable offspring ###

Model3<- glm(Productivity\_zeros ~ female\_temperature\* male\_temperature, family = binomial(link = "logit"), data = Experiment4)

Anova(Model3, type = 3)

### Fecundity ###

Eggs\_zeros<-subset(Experiment4, Eggs\_zeros=='1')

Model4<- glm(eggs ~ female\_temperature\* male\_temperature, data = Eggs\_zeros )

Anova(Model4, type = 2, test.statistic=c("F"))

### Egg hatch proportion ###

Hatch\_zeros<-subset(Experiment4, Hatch\_zeros=='1')

Model5<- glm(hatch\_proportion ~ female\_temperature\* male\_temperature, data = Hatch\_zeros )

Anova(Model5, type = 2, test.statistic=c("F"))

### Total offspring ###

Productivity\_zeros<-subset(Experiment4, Productivity\_zeros=='1')

Model6<- glm(total\_offspring ~ female\_temperature\* male\_temperature, data = Productivity\_zeros )

Anova(Model6, type = 2, test.statistic=c("F"))

**### Experiment 5: Combined effects of elevated developmental and adult temperatures on reproductive success and fertility ###**

Experiment5 <- read\_csv("./Experiment5.csv",

col\_names=TRUE,

na='NA')

### Proportion laying eggs ###

Model1<- glm(eggs\_zeros ~ pre\_mating\_temperature\*post\_mating\_temperature, family = binomial(link = "logit"), data = Experiment5)

Anova(Model1, type = 2)

### Proportion with viable eggs ###

Model2<- glm(hatch\_zeros ~ pre\_mating\_temperature\*post\_mating\_temperature, family = binomial(link = "logit"), data = Experiment5)

Anova(Model2, type = 2)

### Proportion with viable offspring ###

Model3<- glm(larvae\_zeros ~ pre\_mating\_temperature\*post\_mating\_temperature, family = binomial(link = "logit"), data = Experiment5)

Anova(Model3, type = 2)

### Fecundity ###

eggs\_zeros<-subset(Experiment5, eggs\_zeros=='1')

Model4<- glm(eggs ~ pre\_mating\_temperature\*post\_mating\_temperature, data = eggs\_zeros )

Anova(Model4, type = 3, test.statistic=c("F"))

### Egg hatch proportion ###

hatch\_zeros<-subset(Experiment5, hatch\_zeros=='1')

Model5<- glm(hatch\_proportion ~ pre\_mating\_temperature\*post\_mating\_temperature, data = hatch\_zeros )

Anova(Model5, type = 3, test.statistic=c("F"))

### Total offspring ###

productivity\_zeros<-subset(Experiment5, productivity\_zeros=='1')

Model6<- glm(total\_offspring ~ pre\_mating\_temperature\*post\_mating\_temperature, data = productivity\_zeros )

Anova(Model6, type = 3, test.statistic=c("F"))

**### Experiment 6: Effects of elevated developmental temperatures on reproductive success and fertility across generations and gonotrophic cycles ###**

Experiment6 <- read\_csv("./Experiment6.csv",

col\_names=TRUE,

na='NA')

### Proportion laying eggs GC1 ###

Model1<- glm(eggs\_zeros\_GC1 ~ first\_generation\_temp\*second\_generation\_temp, family = binomial(link = "logit"), data = Experiment6)

Anova(Model1, type = 2)

### Proportion with viable eggs GC1 ###

Model2<- glm(hatch\_zeros\_GC1 ~ first\_generation\_temp\*second\_generation\_temp, family = binomial(link = "logit"), data = Experiment6)

Anova(Model2, type = 2)

### Proportion with viable offspring GC1 ###

Model3<- glm(productivity\_zeros\_GC1 ~ first\_generation\_temp\*second\_generation\_temp, family = binomial(link = "logit"), data = Experiment6)

Anova(Model3, type = 2)

### Fecundity GC1 ###

eggs\_zeros\_GC1<-subset(Experiment6, eggs\_zeros\_GC1=='1')

Model4<- glm(Eggs\_GC1 ~ first\_generation\_temp\*second\_generation\_temp, data = eggs\_zeros\_GC1)

Anova(Model4, type = 2, test.statistic=c("F"))

### Egg hatch proportion GC1 ###

hatch\_zeros\_GC1<-subset(Experiment6, hatch\_zeros\_GC1=='1')

Model5<- glm(Hatch\_GC1 ~ first\_generation\_temp\*second\_generation\_temp, data = hatch\_zeros\_GC1)

Anova(Model5, type = 2, test.statistic=c("F"))

### Total offspring GC1###

productivity\_zeros\_GC1<-subset(Experiment6, productivity\_zeros\_GC1=='1')

Model6<- glm(Total\_offspring\_GC1 ~ first\_generation\_temp\*second\_generation\_temp, data = productivity\_zeros\_GC1)

Anova(Model6, type = 2, test.statistic=c("F"))

### Proportion laying eggs GC2 ###

Model7<- glm(eggs\_zeros\_GC2 ~ first\_generation\_temp\*second\_generation\_temp, family = binomial(link = "logit"), data = Experiment6)

Anova(Model7, type = 2)

### Proportion with viable eggs GC2 ###

Model8<- glm(hatch\_zeros\_GC2 ~ first\_generation\_temp\*second\_generation\_temp, family = binomial(link = "logit"), data = Experiment6)

Anova(Model8, type = 2)

### Proportion with viable offspring GC2 ###

Model9<- glm(productivity\_zeros\_GC2 ~ first\_generation\_temp\*second\_generation\_temp, family = binomial(link = "logit"), data = Experiment6)

Anova(Model9, type = 2)

### Fecundity GC2 ###

eggs\_zeros\_GC2<-subset(Experiment6, eggs\_zeros\_GC2=='1')

Model10<- glm(Eggs\_GC2 ~ first\_generation\_temp\*second\_generation\_temp, data = eggs\_zeros\_GC2)

Anova(Model10, type = 2, test.statistic=c("F"))

### Egg hatch proportion GC2 ###

hatch\_zeros\_GC2<-subset(Experiment6, hatch\_zeros\_GC2=='1')

Model11<- glm(Hatch\_GC2 ~ first\_generation\_temp\*second\_generation\_temp, data = hatch\_zeros\_GC2)

Anova(Model11, type = 2, test.statistic=c("F"))

### Total offspring GC2 ###

productivity\_zeros\_GC2<-subset(Experiment6, productivity\_zeros\_GC2=='1')

Model12<- glm(Total\_offspring\_GC2 ~ first\_generation\_temp\*second\_generation\_temp, data = productivity\_zeros\_GC2)

Anova(Model12, type = 2, test.statistic=c("F"))

**### Experiment 4 – example of zero inflation models with zero counts included ###**

Experiment4 <- read\_csv("./Experiment4.csv",

col\_names=TRUE,

na='NA')

### Fecundity ###

model1 <- glmmTMB(eggs ~ female\_temperature\*male\_temperature,

ziformula = ~ female\_temperature\*male\_temperature,

family = poisson,

data = Experiment4)

model2 <- glmmTMB(eggs ~ female\_temperature\*male\_temperature,

ziformula = ~ female\_temperature\*male\_temperature,

data = Experiment4)

Anova(model1, type = 2)

Anova(model2, type = 2)

### Egg hatch proportion ###

model1 <- glmmTMB(hatch\_proportion ~ female\_temperature\*male\_temperature,

ziformula = ~ female\_temperature\*male\_temperature, # Zero-inflation component

family = poisson,

data = Experiment4)

model2 <- glmmTMB(hatch\_proportion ~ female\_temperature\*male\_temperature,

ziformula = ~ female\_temperature\*male\_temperature, # Zero-inflation component

data = Experiment4)

model3 <- glmmTMB(hatch\_proportion ~ female\_temperature\*male\_temperature,

ziformula = ~ female\_temperature\*male\_temperature, # Zero-inflation component

family = binomial(link = "logit"),

data = Experiment4)

model4 <- glmmTMB(hatch\_proportion ~ female\_temperature\*male\_temperature,

ziformula = ~ female\_temperature\*male\_temperature, # Zero-inflation component

family = betabinomial,

data = Experiment4)

Anova(model1, type = 2)

Anova(model2, type = 2)

Anova(model3, type = 2)

Anova(model4, type = 2)