**Introduction**:

**Question 1**: What do tree swallows eat in Tompkins County, New York?

**Question 2**: What predicts aquatic insect content in the diet?

1. **Do age, site, or an interaction between the two predict aquatic insect content in diet?**

Model: Beta Logistic Regression (percent aquatic ~ age\*site + treatment + (1|nestID))

Age levels: Nestling vs. adult

Sample extent: only samples from provisioning (all nestlings, adult female third captures)

1. **Does a mother’s CORT, mass, and/or wing predict the percent aquatic in the diet of her nestlings?**

Model: Beta Logistic Regression, model selection

* (percent aquatic in individual nestling diet ~ mom’s base CORT\*site + 1|nestID)
* (percent aquatic in individual nestling diet ~ mom’s base CORT + site + 1|nestID)
* (percent aquatic in individual nestling diet ~ mom’s stress response\*site + 1|nestID)
* (percent aquatic in individual nestling diet ~ mom’s stress response + site + 1|nestID)
* (percent aquatic in individual nestling diet ~ mom’s dex\*site + 1|nestID)
* (percent aquatic in individual nestling diet ~ mom’s dex + site + 1|nestID)
* (percent aquatic in individual nestling diet ~ mom’s mass\*site + 1|nestID)
* (percent aquatic in individual nestling diet ~ mom’s mass + site + 1|nestID)
* (percent aquatic in individual nestling diet ~ mom’s wing\*site + 1|nestID)
* (percent aquatic in individual nestling diet ~ mom’s wing + site + 1|nestID)

Sample extent: only samples from provisioning (all nestlings, i.e. days 6, 12, and 15)

1. **Does a female’s CORT, mass, and/or wing predict the percent aquatic in her diet?**

Model: Beta Logistic Regression, model selection

* (percent aquatic in mom’s diet ~ mom’s CORT\*site + experimental treatment + 1|nestID)
* (percent aquatic in mom’s diet ~ mom’s CORT + site + experimental treatment + 1|nestID)
* (percent aquatic in mom’s diet ~ mom’s mass\*site + experimental treatment + 1|nestID)
* (percent aquatic in mom’s diet ~ mom’s mass + site + experimental treatment + 1|nestID)
* (percent aquatic in mom’s diet ~ mom’s mass\*capture number + site + experimental treatment + 1|nestID)
* (percent aquatic in mom’s diet ~ mom’s wing\*site + experimental treatment + 1|nestID)
* (percent aquatic in mom’s nestling diet ~ mom’s wing + site + experimental treatment + 1|nestID)

Sample extent: samples from all captures (incubation, provisioning)

**Question 3**: Does aquatic insect content affect nestling morphology?

Model: Linear?? (body mass ~ percent aquatic\*site + (1|nestID))

* Linear mixed model
* Lmer – look at residuals
* Variables bounded below zero are often right skewed; may need to do a log transformation
* No assumption about predictor variables except that there are enough observations per predicator value
* Make sure relationship looks linear
* Assumptions
  + qqplots – residuals need to look fairly symmetric around zero
  + Histogram of residuals (hist(resid(modelname))
  + Make scatterplot of residuals vs. predicted values; homogenous variables assumption
    - Random scatter of points
    - Vertical spread same across
    - No fan shape (this means right skewed)

glmmTMB

* Same authors as lme4 package
* Some beta formulations will not take 0s and 1s, and that is the case with this package

Where to start:

* Try to just fit as linear model
  + Proportion as response
  + Look at residuals and see how it looks
* Sometimes this may work if proportions are between 0.3 and 0.7

Next thing to try:

* Use logit transformation
* Similar to what you would use in a beta regression
* Manually do logit transformation and put in to linear model
* Generalized logit:
  + Rescales things away from zero and one
  + One possibility:
    - Package: gtools – has function called “logit,” does generalized logit
    - Logit help:
      * Default is plain old logit, assumes min and max are zero and one
      * If you specify a separate range for it, it takes that range and scales it
      * First scales and then does logit transformation
      * Make range a tiny bit below and above above values
        + -0.0001, 1.0001
      * Take logit transformation and put in to lmer model
  + Used generalized logit transformation and then fit a linear mixed model to those values

Beyond that:

* Wonky things to try
* 0 and 1 inflated beta regression (zoib)
* Trying to fit a beta but allowing for zeros and ones
* Can you fit these in R with random effects? Unclear.
* None of main packages have random effects
* Glmm adaptive – looks like a pain

Bayesian methods

* Zoib package: function zoib is pretty similar to lmer model, can take random effects, can specify zero and one inflation
* Have defaults for priors
* This could be done without too much overhead, figuring it all out

Tobit model

* Used in social science, economics
* Censored model

Ask around for standard solutions

**Plan: try generalized logit**

* Can look around more to see what is available
* Not many options to fit with zeroes and ones (mostly just zeroes)

**Methods**:

* Fecal sample collection 2019:
  + Collected opportunistically. For nestlings, collected poop from hands or sometimes ground if it didn’t get too dirty, scooping into tube. For adults, collected from defecation at time of capture on hand or clothing, or from paper bags that birds were stored in
  + Feces transferred to 1 mL tubes, stored on ice in field; transferred to -80 for permanent storage
* Extraction: Qiagen Power Soil Kit, following manufacturer’s instructions
* PCR: primers BF2/BR2, done in triplicate and pooled
* Sequencing: Cornell Biotechnology Resource Center
* Post-sequencing processing

**Results**:

**Discussion**:

**Major questions for paper:**

**Question 1: What do tree swallows eat in Tompkins County, New York?**

**Question 1.5: Brood size**

* Put in Question 2B and 2C models

**Question 2: What predicts aquatic insect content in the diet?**

**Question A: Do age, site, or an interaction between the two predict aquatic insect content in diet?**

Model: Beta Logistic Regression: (percent aquatic ~ age\*site + treatment + (1|nestID))

Age question

* Age – nestling vs. adult – this is fine because there are no consistent differences
* Only use provisioning samples

**Question B: Does a mother’s CORT, mass, and/or wing predict the percent aquatic in the diet of her nestlings?**

Include all available mom samples

Model: Beta Logistic Regression: (percent aquatic in individual nestling diet ~ mom’s CORT + mom’s mass + mom’s wing + site + 1|nestID)

Model selection:

* CORT
* Mass
* Wing
* Brood size?
* All models: site + 1|nestID
  + For each of models, include an interaction with site and no interaction with site

I’ve made a lot of figures here but nothing seems to show a clear relationship with nestling diet except perhaps experimental treatment and site.

This figure is made just with nestling day 12 samples. Also, note that this figure looks a little different than the boxplots in Question 2A because this only includes nestlings for which there are also adult samples. I need to go back and change the code so that this section of analyses also includes female information for females that do not also have fecal samples.

**Question C: Does a female’s CORT, mass, and/or wing predict the percent aquatic in her diet?**

Include samples from incubation and provisioning.

* Look at figure with percent aquatic
* Don’t worry about interaction with stage – don’t include stage in models
* Include treatment as covariate

Model selection:

* CORT
* Mass (capture x mass interaction)
* Wing
* Brood size?
* All models: site + 1|nestID
  + For each of models, include an interaction with site and no interaction with site

Model: Beta Logistic Regression: (percent aquatic ~ CORT + mass + site)

Like Question 2B, only experimental treatment and site seems to show any sort of relationship with diet.

Note that here, we’re only looking at third female captures (i.e. captures during provisioning)

**Question 3: Does aquatic insect content affect nestling morphology?**

Model: Linear?? (body mass ~ percent aquatic\*site + (1|nestID))

Differences between mass at sites

Day 15 – Day 12

* Do absolute mass gained