Bugs Below Zero:
Do Trout Prefer Certain Types of Invertebrates During Winter?

Objectives: The primary goal of this exercise is to examine feeding preferences of a population of brown trout and determine whether this population shows preference toward certain types of food sources during the winter season. To achieve this goal, you will:

1. Utilize a common electivity index, *Manly's alpha,* to interpret whether trout show preference towards certain prey and if so, if preference varies by trout size class
2. Create a table to visualize your results
3. Discuss the greater significance of your findings

Introduction:
Winter is a difficult period for stream trout. Like other animals that remain active throughout the winter season, fish are reliant on an abundant food supply to make it through the season. Here we will examine data from trout streams in southeast Minnesota to determine whether brown trout in these populations preferentially select certain prey items over others, as opposed to simply eating prey at random in proportion to their abundance in the environment.

We can compare this to our behavior at an all-you-can-eat buffet. Let's say there were 10 pieces of pepperoni pizza available, 56 chicken strips, 26 pickles, and 8 pieces of chocolate cake. You could fill your plate proportionally, selecting 1 piece of pizza, 6 chicken strips, 3 pickles, and 1 piece of cake. On the other hand, you could instead show preference for certain items, selecting instead 7 pieces of pizza, 1 chicken strip, and 2 pieces of cake, and no pickles. In this example, it certainly seems like you are showing preference for pizza and cake. We can use electivity indices to formally assess whether organisms exhibit preference for certain items.

There are several electivity or selectivity indices. Here, we will use an index called Manly's alpha to estimate prey selection of trout to determine whether trout of different size classes consumed prey in proportion to that numerically available in the environment. Manly's alpha (α) is defined as:

$$\alpha_i = \frac{r_i}{n_i}\left(\frac{1}{\Sigma\frac{r_i}{n_i}}\right)$$

where:

α_i is Manly's alpha for prey type *i*,
r_i is the proportion of prey taxon *i* in the diet,
n_i is the proportion of each prey taxon *i* available in the environment.

Values of $\alpha > 1/m$, where *m* is the total number of prey types available, suggest selective feeding for that prey item, values where $\alpha = 1/m$ indicate neutral selection, and values $< 1/m$ suggest that prey item is avoided.

We could use Manly's alpha to examine our buffet example:

	# of Items on Buffet	% Composition on Buffet (n_i)	# of Items on Plate	% Composition on Plate (r_i)	r_i/n_i	Manly's Alpha
Pizza	10	0.10	7	0.70	7.00	0.72
Chicken	56	0.56	1	0.10	0.18	0.02
Pickles	26	0.26	0	0.00	0.00	0.00

Cake	8	0.08	2	0.20	2.50	0.26

If we look at the Manly's alpha value for pizza, and plug appropriate numbers into the formula shown above we get:

$$\alpha_{pizza} = \frac{0.70}{0.10}\left(\frac{1}{\frac{0.70}{0.10}+\frac{0.10}{0.56}+\frac{0.00}{0.26}+\frac{0.2}{0.08}}\right)$$

This can be simplified to:

$$\alpha_{pizza} = 7.0\left(\frac{1}{7.0+0.18+0.00+2.50}\right) = 0.72$$

Recall that alpha values greater than 1/*m* indicate preference. In this scenario *m* is 4, as we have four potential items on the buffet to select from. So, 1/*m* = 0.25. Since 0.72 is greater than 0.25, we have evidence that pizza is a preferred item. *What can you conclude about the other items on the buffet?*

Now, moving on to our real-world example involving trout feeding during winter. Below are data from two different trout streams. In each stream, you are given the percent composition of invertebrate taxa that make up the diet of small trout and large trout during the winter season. You are also given the percent composition of these taxa as they are found in the environment. Use the data to determine preferred (and avoided!) taxa.

Tasks:

Prior to working with the data, answer these questions:

What is your null hypothesis/hypotheses? After visually examining the data, do your preliminary expectations coincide with this hypothesis? Explain.

Now, begin working with the data. Calculate Manley's alpha values for all taxa.

What do the data show? Which taxa are preferred? Avoided? Do trends differ for small vs. large trout?

Summary questions:

1. Put yourself into the shoes of a fisheries manager. What prey species seem to be most important for brown trout? Do you see similar trends for both streams?

2. Data for large chironomid larva, along with chironomid pupa and adults primarily represent winter-emerging species. What is the broader significance of these results? Research shows that winter-emerging species are restricted to certain temperatures; in other words, if winter temperatures increase due to climate change, certain species that are now abundant in the winter may not be able to thrive in warmer climates. What might be consequences if temperatures increased such that winter-emerging taxa were not as abundant as they are in our current climate?

3. How would you communicate the significance of your results to the broader public?

Percent numerical composition of prey items in the diet of small and large brown trout and in the stream environment for Cold Spring Brook. Data modified from Anderson (2012).

Taxon	% Composition in Diet (Small Trout)	% Composition in Diet (Large Trout)	% Composition in Environment
Baetidae (mayfly)	1.4	0.2	6.9
Large chironomid larvae (midge)	11.3	0.8	6.7
Small chironomid larvae (midge)	1.1	0.1	18.2
Limnephilidae (caddisfly)	6.3	22.6	1.2
Gammeridae (scud)	76.5	51.2	62.8
Physellidae (snail)	0.9	23.3	1.1
Other Prey	2.5	1.9	3.1

Percent numerical composition of prey items in the diet of small and large brown trout and in the stream environment for the Whitewater River. Data modified from Anderson (2012).

Taxon	% Composition in Diet (Small Trout)	% Composition in Diet (Large Trout)	% Composition in Environment
Baetidae (mayfly)	2.7	2.7	10.8
Ephemerellidae (mayfly)	0.3	0.0	3.8
Large chironomid larvae (midge)	49.4	17.0	18.4
Small chironomid larvae (midge)	2.3	0.2	28.4
Chironomid pupa (midge)	8.8	3.3	1.0
Chironomid adult (midge)	0.0	1.3	1.9
Simuliidae (black fly larva)	1.6	1.9	4.2
Brachycentridae (caddisfly)	8.5	46.8	2.7
Gammeridae (scud)	21.0	15.6	4.6
Physellidae (snail)	2.9	5.1	5.1
Acari	0.1	0.2	3.0
Other Prey	2.3	5.9	16.1

Resources:

Anderson, A.M. 2012. Winter-emerging Chironomidae (Insecta: Diptera) in Minnesota trout streams. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/142960.

Anderson, A.M. E. Mittag, B. Middleton, B. Vondracek, & L.C. Ferrington Jr. 2016. Winter diets of brown trout populations in southeastern Minnesota and the significance of winter-emerging invertebrates. Transactions of the American Fisheries Society 145:206-220.