The Relationship Between Foraging Behavior and Offspring Size in Lizards, Snakes, and Amphisbaenians

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**Introduction**

Offspring size is one aspect of an organism’s traits that is important for determining future success and survival. Size of offspring can be influenced aspects such as diet and foraging method. The way an animal forages is one element that has many different outcomes such as altering behavior, efficiency in completing necessary survival tasks, and the evolution of body shape and size (Huey and Pianka 1981). These elements can change how an animal obtains energy to have the best reproductive output and provide the best chance for the advancement of future generations.

Many factors can influence how an animal tends to forage. One way in which they choose how they forage is being as efficient as possible in various ways. This can be called optimal foraging which usually maximizes some optimality criterion such as the best number of offspring or the most net energy acquired (Smith and Fretwell 1974; Křivan 1996). However, offspring and the amount of energy used or acquired are affected by more than just foraging modes, but they are also impacted by predation. Predation relates to energy expenditure since the organism must assess how they spend their energy based on the risk of encountering a predator and where their food is located in relation to said predator (Verdolin 2006).

Foraging behaviors are affected by many of the previous conditions, but can be categorized into some categories based on the way in which they obtain their food. In lizards, snakes, and amphisbaenians, some categorizations include widely foraging, sit and wait behavior, and a mixture of the two (Padilla Perez et al. 2022). These foraging types may have evolved through natural selection in addition to how well it benefits the species in regards to the energy spent gathering sustenance (Anderson and Karasov 1981). Each differing species of lizard will have a preferred foraging method depending on what it eats and how much energy it is willing to invest. Widely foraging lizards tend to spend around 1.5 times more energy than a sit and wait species; however, the energy gained can be as high as 2.1 times higher than the sit and wait foragers (Huey and Pianka 1981). This energy expenditure and gain may have an important role in the evolution of offspring size based on what foraging mode is displayed. For this analysis, it is predicted that there will be a considerable difference between the offspring size in correlation to the foraging behavior of the parent.

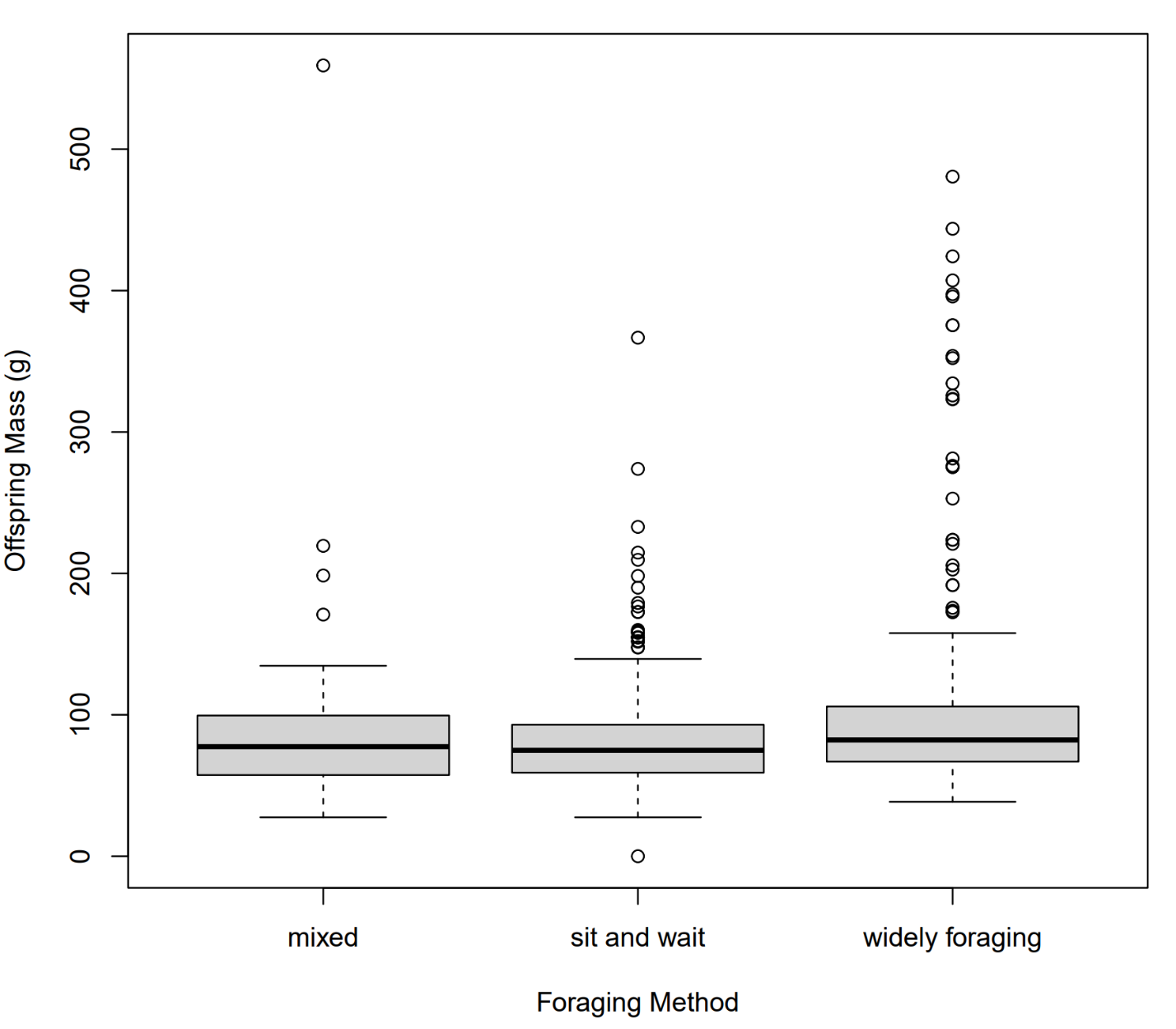
**Materials and Methods**

The data used to examine foraging mode and offspring size in lizards, amphisbaenians, and snakes comes from Padilla Perez et al. 2022. There were 600 species compiled from published works that were collected in varying locations that were used in determining how offspring size correlates with foraging methods. However, Padilla Perez et al. 2022 used only 485 species of solely lizards in their analysis of reproductive effort associated with foraging modes and their phylogeny. The additional 115 amphisbaenians and snake species were used with the 485 lizard species in this analysis where the offspring size, in grams, were compared to the species foraging type being widely foraging, sit and wait, or a mix of the two.

Analysis of offspring mass in regards to foraging type was calculated using version 4.2.2. of RStudio. A one-way analysis of variance (ANOVA) was used with the 600 species based on the three foraging modes with solely the offspring mass to see if there were any significant differences. A Welch two sample t-test, using version 4.2.2. of R, was then calculated to see which of the foraging methods varied from the other types between foraging groups. A boxplot was also made using R which shown the average offspring mass with the outlier masses based on the three foraging types (Figure 1).

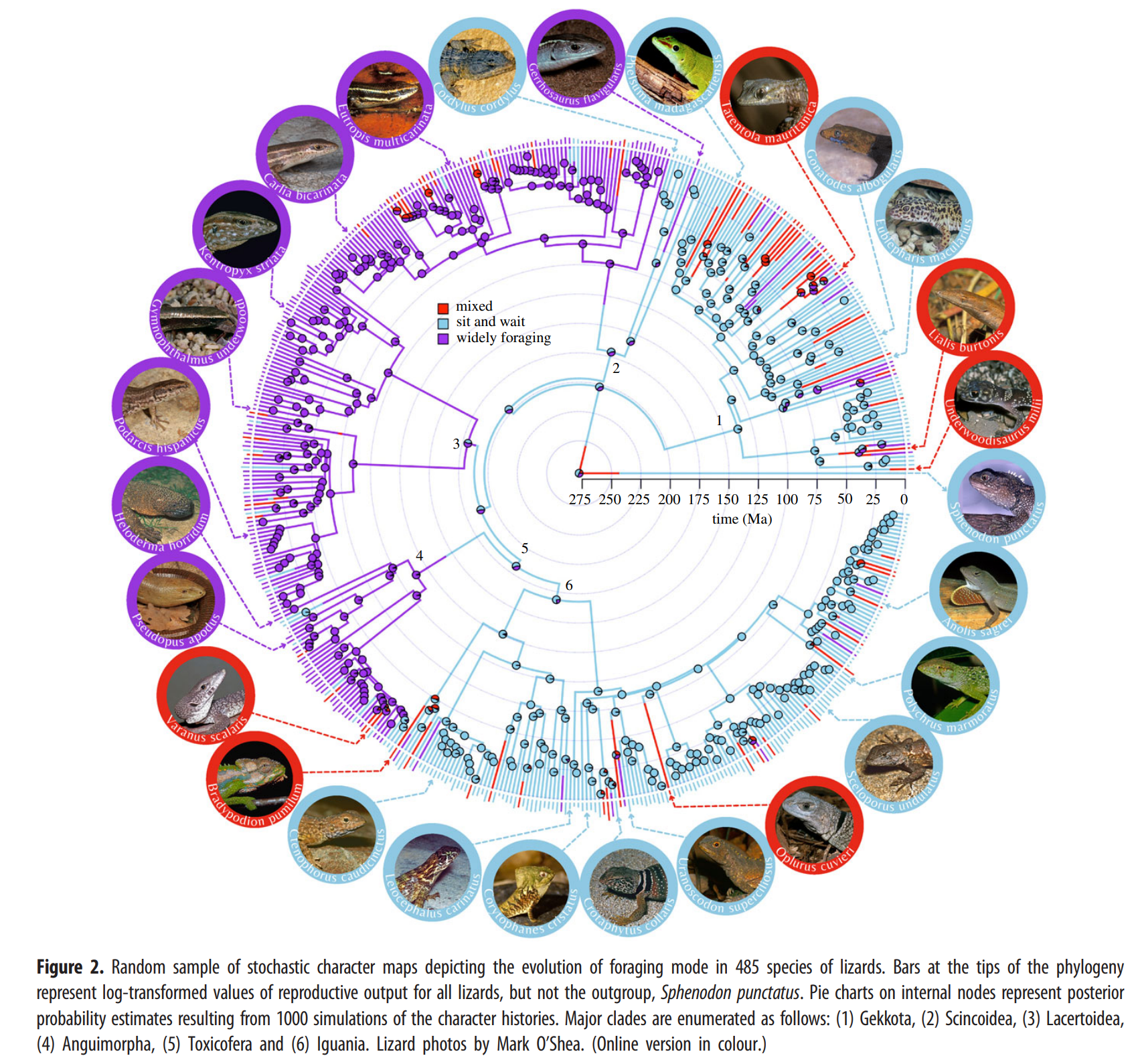
**Results**

Foraging modes produced a different average of offspring mass for each of the three categories. The highest average offspring mass was found to be the widely foraging method that had an average offspring mass of 105.7g mass while the lowest average came from sit and wait foragers at 83.67g (Figure 1). The middle foraging type, mixed, produced an average of 90.57g. However, each of the foraging methods had a different number of species that were used to calculate the previous listed averages. Widely foraging offspring mass average was calculated using 265 different species with sit and wait and mixed having 269 species and 66 species respectively. Within the data, two numbers appear quite differently than others. The mixed foraging method had a species that produced an offspring greater than others at almost 600 grams while the sit and wait method had one data point for which the offspring measured zero grams. These species were *Varanus komodoensis* (Komodo dragon) of Indonesian islands and surrounding territory and *Sphenodon punctatus* from New Zealand respectively. Padilla Perez et al. 2022 did not mention why the Komodo dragon had a measured offspring mass of zero.

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**Figure 1:** The offspring mass in grams categorized on the three types of foraging methods

An ANOVA was also used in testing the correlation between foraging modes and offspring and calculated in R. Based on the 600 total species used from Padilla et al. 2022, it was found that the F value came to be 8.491 using the one-way ANOVA with the critical F value being 3.011. A phylogeny was also created depicting the three foraging types of the collected lizard species as well as major clades and divergence time measured in millions of years represented by Figure 2 (Padilla Perez et al. 2022). This phylogeny indicates that some of the older foraging types, for the most part, branches off from the sit and wait foragers around 200 million years ago.

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**Discussion**

Based on the ANOVA for 600 species categorized in three different foraging methods, the critical F value comes to 3.011 using a probability level of 0.05. Using the calculated F value from the ANOVA of 8.491, it shows there is a difference between the foraging modes and offspring mass. Based on furthering testing using a Welch two sample t-test using p-level of 0.05, it was found that the difference between foraging modes is between the sit and wait behavior and the widely foraging method. This may suggest that the two different foraging types, sit and wait and widely foraging, have evolved differently over the millions of years depicted in Figure 2. However, further testing and larger samples may be needed to establish a certain understanding in how foraging behavior correlates with offspring size.

Padilla Perez et al. 2022 listed 600 species but tested their reproductive effort hypothesis based on only 485 lizard species out of the total 600 species which included an additional 115 amphisbaenian and snake species. In addition, the sample size for each of the foraging behaviors had various number of species. Sit and wait species had 269 individuals while the widely foraging and mixed types had 265 and 66 species respectively. An analysis with a more similar number of sampling and species count may more accurately depict how the foraging mode impacts the offspring size. In addition, more factors such as energy use and predator encounters as well as numerous other factors could be considered which may support or alter the findings. Based on the previous analyses though, it appears that the widely foraging species have evolved differently over the millions of years than that those that use the sit and wait foraging behavior.

**References**

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