# Alligator Food Choice

Florida Alligator Food Choice - Zihan Wang, Yiquan Xiao, Yusen Wang

## 1 Introduction

## 1.1 Background and Literature Review

Understanding the dietary habits of alligators is pivotal for ecological balance and conservation strategies. Alligators, as apex predators, play an essential role in their ecosystems, influencing prey populations and nutrient distribution. Their diet, influenced by a range of factors including habitat, biological traits, and prey availability, provides insights into their ecological roles and adaptability to environmental changes. This project aims to investigate the dietary patterns of alligators across different Florida lakes, exploring how factors such as location, gender, and size impact their primary food choices.

The motivation for this study arises from the necessity to enhance our understanding of alligator behavior and its implications for ecosystem health. Knowledge of how various factors affect alligator food choices can inform conservation efforts, guide the management of alligator populations, and help predict the effects of environmental shifts on these key predators.

The dietary patterns and conditions of American alligators (Alligator mississippiensis) have been the focus of extensive research due to their pivotal role in maintaining the ecological balance within their habitats. Studies by Delany et al. [2] and Delany and Abercrombie [1] have laid the groundwork in understanding the complex interplay between alligator size, gender, and their preferred prey, unveiling how these factors dictate the diet composition across various Floridian lakes. These foundational works not only highlight the dietary shift from invertebrates to larger vertebrates as alligators grow but also emphasize the significance of habitat characteristics in influencing these patterns.

Further contributions by Rice [4] provide a closer examination of the dietary preferences and physical conditions of adult alligators in central Florida, identifying a strong preference for fish and noting considerable variances in dietary habits across different lake environments. This research underscores the importance of prey availability and habitat diversity in shaping the feeding behavior and overall health of alligators. On the other hand, the study by Platt et al. [3] focuses on the lesser-studied juvenile stage of alligators, exploring how the unique estuarine ecosystems of the Upper Lake Pontchartrain influence the diet of young alligators. Their findings reveal a reliance on crustaceans and small fish, shedding light on the early dietary adaptations that enable juvenile alligators to thrive in their specific habitats.

## 1.2 Data Description

The study of alligator food choices involves several variables classified into independent and dependent categories, with distinctions between continuous, ordinal, and nominal types. Below is a detailed description of these variables:

### 1.2.1 Independent Variables

- **Lake of Capture (L):** This nominal variable identifies the lake where each alligator was captured. The categories are as follows: *Hancock, Oklawaha, Trafford, George*
- **Gender (G):** Another nominal variable indicating the gender of the alligator. It is a binary variable and has two categories: *Male, Female*.
- **Size (S):** This is a binary ordinal variable that classifies alligators based on their length (in meters). The categories are: $\leq 2.3$, $> 2.3$

### 1.2.2 Dependent Variable

- **Primary Food Type**: The primary food type, in volume, found in an alligator's stomach is a nominal polytomous dependent variable with five categories: *Fish, Invertebrate, Reptile, Bird, Other*

## 1.3 Research Questions

Our study aims to explore the dietary habits of alligators, focusing on the primary food type found in their stomachs. We classify these alligators based on the lake of capture, gender, and size. The research questions are structured to unravel the complex interactions between these variables and their impact on the alligator's primary food choice. To be specific, we are interested in:

- Investigate the associations between the primary food type of alligators and each independent variables (lake of capture, gender, and size) with conditioning on the other remaining independent variables.
- Explore the associations between the independent variables (lake of capture, gender, and size) themselves
- Analyze how the combination of lake of capture, gender, and size, along with the potential interactions between these factors, affects the primary food choice of alligators.

## 2. Preliminary Data Analysis

## 2.1 Marginal Distribution of Primary Food Choice

| Size | | <= 2.3 | > 2.3 |
|---|---|---|---|
| Lake | Gender | | |
| Hancock | Male | L1 | L9 |
| | Female | L5 | L13 |
| Oklawaha | Male | L2 | L10 |
| | Female | L6 | L14 |
| Trafford | Male | L3 | L11 |
| | Female | L7 | L15 |
| George | Male | L4 | L12 |
| | Female | L8 | L16 |

*Table 1: Li Definition*

In this section, we will explore the marginal distribution of the primary food choice according to the conditions of independent variables. To do that, we define L1 to be a variable that counts the number of specific conditions (Lake = Hancock, Gender = Female, Size $\leq$ 2.3 meters) met by each alligator. Then, we can construct 5 one-way frequency tables depending on the categories of primary food choice. Using the same way, we can define L2, …, L16 and construct corresponding one-way frequency tables (shown in Table 1). Here, only L9 has no 0 count in 5 of its corresponding one-way frequency tables. Therefore, we will only focus on L9 in order to have appropriate goodness-of-fit (GOF) tests. The result of GOF tests for L9 is shown in Table 2. And the barplots for each one-way table of L9 is shown in Figure 1

| | | L9 tables (for each Primary Food Type) | | | | |
|---|---|---|---|---|---|---|
| Distribution | $G^2$ test | Fish | Invertebrate | Reptile | Bird | Other |
| Binomial | $G^2/df$ | 7.22 | 6.64 | 5.3 | 2.82 | 2.21 |
| | p-value | 7.35E-04 | 1.31E-03 | 5.00E-03 | 5.96E-02 | 1.10E-01 |
| Poisson | $G^2/df$ | 18.61 | 18.20 | 11.44 | 9.76 | 3.02 |
| | p-value | 8.26E-09 | 1.25E-08 | 1.07E-05 | 5.76E-05 | 4.86E-02 |
| nBinomial | $G^2/df$ | 37.4 | 36.58 | 22.98 | 19.62 | 6.13 |
| | p-value | 9.65E-10 | 1.47E-09 | 1.64E-06 | 9.43E-06 | 1.33E-02 |

*Table 2: Likelihood Ratio Test for L9*

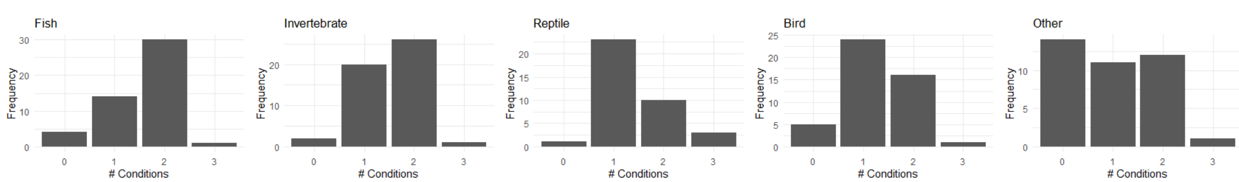


*Figure 1: Barplots for each one-way frequency tables of L9*

The p-values of GOF tests (shown in Table 2) for fish/invertebrate/reptile L9 data are far less than 0.05, suggesting that indicating that none of the tested distributions (Binomial, Poisson, Negative Binomial) suitably models the observed data. In contrast, for bird/other L9 data, p-values of GOF tests for Binomial distribution are larger than 0.05, indicating that Binomial distribution is a reasonable fit for these observed data.

Figure 2 shows the hanging rootograms and generalized distribution plots of "best fit" distribution (here, the "best fit" distributions are all binomial distribution) for one-way frequency table where primary food type is Other. The conclusions drawn from these plots are the same as those drawn from the GOF test. For example, in the hanging rootogram for “Other” L9 data, the bars do not deviate significantly from the expected values, as indicated by the close proximity of the base line to the end of the bars. Also, in the binomialness plot for “Other” L9 data, the red line in the binomialness plot is within the confidence intervals, suggesting that the logit of the binomial probabilities changes linearly with the number of specific conditions met by alligators. Similar things happen for “Bird” L9 data.

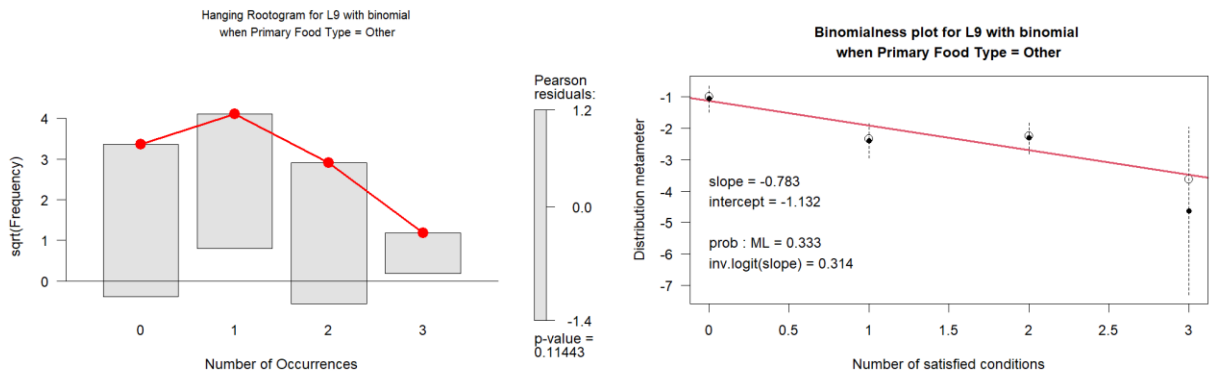


*Figure 2: Hanging Rootgram of Binomial dsitribution and Binomialness plot for L9 when Primary Food Type = Other*

## 2.2 Stratified Analysis

Controlling 2 background variables makes our data sparse, so we decide to control 1 background variable each time

### 2.2.1 Lake with background variable Gender

| | Measures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Gender | ContCoef | ContCoefLB | ContCoefUB | CramerV | CramerVLB | CramerVUB | Lambda | LambdaLB | LambdaUB |
| Male | 0.488 | 0.449 | 0.610 | 0.323 | 0.290 | 0.444 | 0.173 | 0.097 | 0.321 |
| Female | 0.489 | 0.429 | 0.612 | 0.324 | 0.274 | 0.447 | 0.237 | 0.138 | 0.356 |

*Table 3: Association Measures (Lake by Gender)*

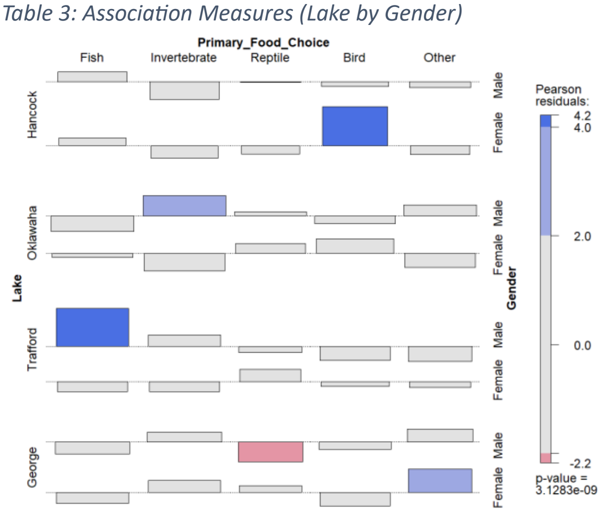


*Figure 3: Association Plot (Lake, Primary Food Choice, Gender)*

The Pearson's Chi-squared $X^2$ test, Likelihood Ratio $G^2$ test, and general test from CMHtest indicate a significant association between lake of capture and primary food type among male/female alligators, with p-values ($X^2$: 4.04e-4/8.60e-4, $G^2$: 2.90e-5/5.65e-4, general: 4.54e-4/9.63e-4) far below the typical alpha level of 0.05. For both males and females, the confidence interval for each association measure (shown in Table 3) does not include 0, which led to the same conclusion.

For male alligators, Contingency Coefficient and Cramer's V both indicate a moderate association between the lake of capture and primary food type. Goodman Kruskal’s Lambda suggests that knowing the lake of capture can improve the prediction of the primary food type by about 17.33%, which, while modest, is not negligible. For female alligators, the measures of association are very similar to those for males, indicating a moderate association between lake and primary food type among females. Goodman Kruskal’s Lambda for females is higher (23.68%) than for males, suggesting that lake of capture is a slightly better predictor of primary food type for female alligators than for male alligators.

From the association plot (shown in Figure 3), we can see that the p-value (3.13e-9) is much less than 0.05, which indicates that the overall association between lake and primary food type, stratified by gender, is statistically significant. The blue tiles suggest that male alligators from Trafford/Oklawaha are more likely to consume fish/invertebrate than expected, and female alligators from Hancock/George are more likely to consume bird/other than expected. While the red tiles suggest that male alligators from George are less likely to consume reptile than expected.

### 2.2.2 Lake with background variable Size

| | Measures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Size | ContCoef | ContCoefLB | ContCoefUB | CramerV | CramerVLB | CramerVUB | Lambda | LambdaLB | LambdaUB |
| $\leq 2.3$ | 0.550 | 0.498 | 0.674 | 0.381 | 0.331 | 0.527 | 0.189 | 0.104 | 0.386 |
| $> 2.3$ | 0.594 | 0.531 | 0.680 | 0.427 | 0.362 | 0.536 | 0.303 | 0.186 | 0.418 |

*Table 4: Association Measures (Lake by Size)*

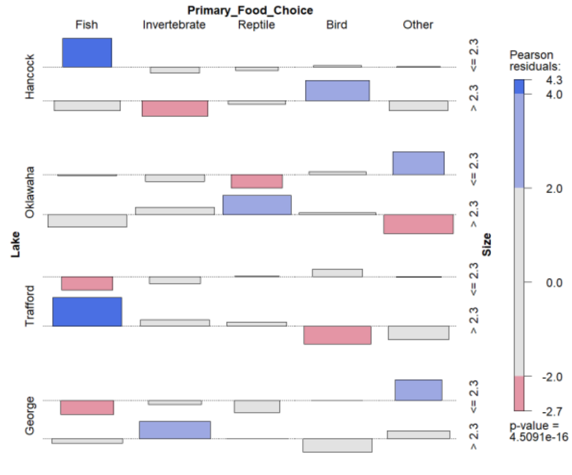


*Figure 4: Association Plot (Lake, Primary Food Choice, Size)*

$X^2$ test, $G^2$ test, and general test from CMHtest indicate a significant association between lake of capture and primary food type among small ($\leq 2.3$) / large ($> 2.3$) alligators, with p-values ($X^2$: 6.98e-4/1.52e-11, $G^2$: 1.21e-5/9.44e-12, general: 8.17e-4/1.93e-11) far below the typical alpha level of 0.05. For both small and large alligators, the CI for each association measure (shown in Table 4) does not include 0, which led to the same conclusion.

For small alligators, the Contingency Coefficient is 0.55 and Cramer's V is 0.381, indicating a moderate association between lake of capture and primary food type. Goodman Kruskal's Lambda is 0.1887, suggesting that knowing the lake of capture provides a moderate predictive power over the primary food type. The association measures for large alligator are larger than those for small alligators, indicating a stronger association than in smaller alligators.

From the association plot (shown in Figure 4), we can see that the p-value (4.51e-16) is much less than 0.05, which indicates that the overall association between lake and primary food type, stratified by size, is statistically significant. The blue tiles suggest that small alligators from Hancock/Oklawaha/George are more likely to consume fish/other/other than expected, and large alligators from Hancock/Oklawaha/Trafford/George are more likely to consume bird/reptile/fish/invertebrate than expected. While the red tiles suggest that small alligators from Oklawaha/Trafford/George are less likely to consume reptiles/fish/fish than expected, and large alligators from Hancock/Oklawaha/Trafford are less likely to consume invertebrate/other/birds than expected.

### 2.2.3 Gender with background variable Lake

| | Measures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Lake | ContCoef | ContCoefLB | ContCoefUB | CramerV | CramerVLB | CramerVUB | Lambda | LambdaLB | LambdaUB |
| H | 0.334 | 0.216 | 0.546 | 0.355 | 0.221 | 0.652 | 0.200 | 0.000 | 0.550 |
| O | 0.437 | 0.319 | 0.572 | 0.486 | 0.337 | 0.697 | 0.345 | 0.115 | 0.621 |
| T | 0.456 | 0.329 | 0.611 | 0.513 | 0.348 | 0.772 | 0.400 | 0.111 | 0.696 |
| G | 0.323 | 0.250 | 0.490 | 0.342 | 0.258 | 0.563 | 0.083 | 0.000 | 0.423 |

*Table 5: Association Measures (Gender by Lake)*

$X^2$ test, $G^2$ test, and general test from CMHtest indicate that there is a significant association between gender and primary food type among Oklawaha/Trafford alligators (p-values: $X^2$: 3.23e-3/9.43e-3, $G^2$: 1.83e-3/7.67e-3, general: 3.59e-3/1.06e-2) but there is no association between them among Hancock/George alligators (p-values: $X^2$: 0.206/0.178, $G^2$: 0.190/0.073, general: 0.216/0.186). The CI for association measures (shown in Table 5) leads to the same conclusion: For Oklawaha/Trafford alligators, the CI for each association measure does not include 0. For Hancock/George alligators, the CI for Goodman Kruskal's Lambda includes 0.

For Oklawaha/Trafford alligators, the high Contingency Coefficient and Cramer's V indicate a strong association between gender and primary food type. High Goodman Kruskal's Lambda value suggests that knowing the gender provides a strong predictive power over the primary food type.

### 2.2.4 Gender with background variable Size

| | Measures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Size | ContCoef | ContCoefLB | ContCoefUB | CramerV | CramerVLB | CramerVUB | Lambda | LambdaLB | LambdaUB |
| $\leq 2.3$ | 0.222 | 0.131 | 0.448 | 0.228 | 0.132 | 0.501 | 0.139 | 0.000 | 0.412 |
| $> 2.3$ | 0.474 | 0.394 | 0.552 | 0.538 | 0.429 | 0.661 | 0.486 | 0.276 | 0.600 |

*Table 6: Association Measures (Gender by Size)*

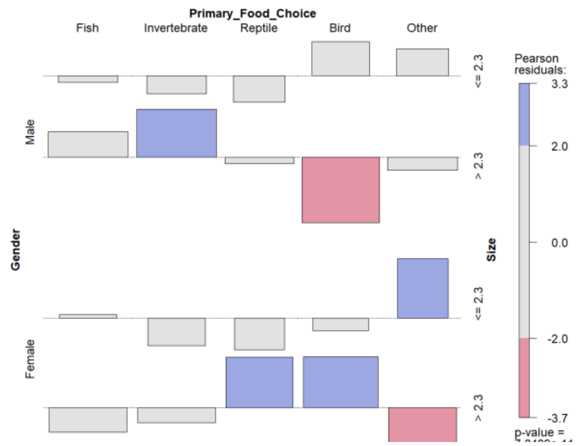


*Figure 5: Association Plot (Gender, Primary Food Choice, Size)*

$X^2$ test, $G^2$ test, and general test from CMHtest indicate that there is a significant association between gender and primary food type among large alligators (p-values: $X^2$: 2.85e-8, $G^2$: 1.46e-9, general: 3.27e-8) but there is no association between them among small alligators (p-values: $X^2$: 0.401, $G^2$: 0.391, general: 0.408). The confidence intervals for association measures lead to the same conclusion: For large alligators, the CI (shown in Table 6) for each association measure does not include 0. For small alligators, the CI for Goodman Kruskal's Lambda includes 0. For large alligators, the high Contingency Coefficient and Cramer's V indicate a strong association between gender and primary food type. High Goodman Kruskal's Lambda value suggests that knowing the gender provides a strong predictive power over the primary food type.

From the association plot (shown in Figure 5), we can see that the p-value (7.85e-11) is much less than 0.05, which indicates that the overall association between gender and primary food type, stratified by size, is statistically significant. The blue tiles suggest that large male alligators are more likely to consume invertebrate than expected, and small/large female alligators are more likely to consume other/(reptile&bird) than expected. While the red tiles suggest that large male/female alligators are less likely to consume bird/other than expected.

### 2.2.5 Size with background variable Lake

| | Measures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Lake | ContCoef | ContCoefLB | ContCoefUB | CramerV | CramerVLB | CramerVUB | Lambda | LambdaLB | LambdaUB |
| H | 0.453 | 0.314 | 0.611 | 0.508 | 0.331 | 0.772 | 0.478 | 0.158 | 0.727 |
| O | 0.563 | 0.502 | 0.634 | 0.681 | 0.581 | 0.821 | 0.480 | 0.304 | 0.720 |
| T | 0.598 | 0.526 | 0.673 | 0.745 | 0.618 | 0.910 | 0.571 | 0.285 | 0.846 |
| G | 0.454 | 0.329 | 0.586 | 0.510 | 0.349 | 0.723 | 0.125 | 0.000 | 0.563 |

*Table 7: Association Measures (Sizer by Lake)*

$X^2$ test, $G^2$ test, general and rmeans tests from CMHtest indicate that there is a significant association between size and primary food type among alligators captured from Hancock/Oklawaha/Trafford/George, with p-values ($X^2$: 1.63e-2/3.00e-6/1.07e-5/7.19e-3, $G^2$: 1.20e-2/5.38e-8/1.57e-6/2.10e-3, general: 1.83e-2/3.72e-6/1.39e-05/8.06e-3, rmeans: 7.45e-3/8.74e-3/1.62e-06/1.98e-3) far below the typical alpha level of 0.05. For alligators from all lakes, the CI for each association measure (shown in Table 7) does not include 0, which led to the same conclusion.
For alligators from all lakes, the high Contingency Coefficient and Cramer's V indicate a strong association between gender and primary food type. For alligators from Hancock/Oklawaha/Trafford, high Goodman Kruskal's Lambda value suggests that knowing the gender provides a strong predictive power over the primary food type. However, for alligators from George, the Goodman Kruskal's Lambda is much lower, which suggests that size is a much poorer predictor of primary food type for George alligators than it is for Hancock/Oklawaha/Trafford alligators.

### 2.2.6 Size with background variable Gender

| | Measures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Gender | ContCoef | ContCoefLB | ContCoefUB | CramerV | CramerVLB | CramerVUB | Lambda | LambdaLB | LambdaUB |
| Male | 0.460 | 0.367 | 0.556 | 0.518 | 0.395 | 0.670 | 0.333 | 0.195 | 0.544 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Female | 0.492 | 0.401 | 0.581 | 0.566 | 0.438 | 0.714 | 0.361 | 0.200 | 0.575 |

*Table 8: Association Measures (Size by Gender)*

$X^2$ test, $G^2$ test, general and rmeans tests from CMHtest indicate that there is a significant association between size and primary food type among male/female alligators, with p-values ($X^2$: 4.18e-6/7.74e-7, $G^2$: 1.85e-6/4.23e-7, general: 4.74e-6/3.72e-6, rmeans: 7.45e-3/2.76e-4) far below the typical alpha level of 0.05. For both male and female alligators, the CI for each association measure (shown in Table 8) does not include 0, which led to the same conclusion.

For both male and female alligators, the high Contingency Coefficient and Cramer's V indicate a strong association between size and primary food type. The Goodman Kruskal's Lambda value suggests that knowing the size provides a moderate predictive power over the primary food type.

## 2.3 Doubledecker Plot

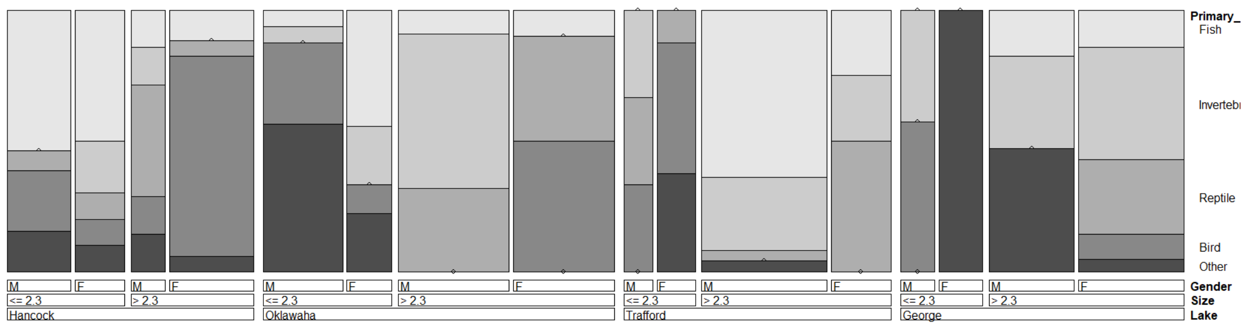


*Figure 6: Doubeldecker Plot*

The Doubledecker plot (shown in Figure 6) clearly shows that the primary food choices of alligators significantly vary depending on the lake in which they reside. In Lake Hancock, alligators have a more varied diet across different types. In contrast, in the other three lakes, not all food types are represented within certain categories. In Lake Oklawaha, the food preferences of alligators significantly vary by size. Larger alligators primarily consume invertebrates, reptiles, and birds, while smaller alligators, particularly males, show a strong preference for other food sources. In Lake Trafford, there is also a notable difference in food choices based on the size of the alligator. Smaller alligators tend to prefer food sources such as birds and others, while larger alligators favor invertebrates and fish. Additionally, in this lake, the difference in food preferences between male and female alligators is more pronounced, regardless of size. In Lake George, there is a significant lack of detailed data on the food choices of small-sized alligators. However, the data shows that large-sized alligators exhibit a much greater variation in their diet compared to those in other lakes.

We also analyzed the doubledecker plot for Lake, Size, and Gender separately. From the marginal categories, we observed that the distribution of food choices among alligators in Lake Oklawaha is the closest to uniform compared to other lakes. In Lake Hancock, birds and fish are the primary food sources. In Lake Trafford, fish dominate the diet, while in Lake George, other types of food are most prevalent. Focusing solely on the marginal data for gender, female alligators show a preference for birds and other types of food sources, whereas male alligators favor fish and invertebrates more. Upon examining the marginal data for size, as previously noted, large-sized alligators tend to have a more diverse range of food choices, while small-sized alligators show a marked preference for birds and other types of food.

## 3 Peer Assessment

Zihan Wang is responsible for the code & analysis for section 2.1. Yiquan Xiao is responsible for the code & analysis for section 2.2. Yusen Wang is responsible for code & analysis for section 2.3 and writing of the report.

## References

[1] Michael F. Delany and C. L. Abercrombie. “American alligator food habits in northcentral Florida”. In: Journal of Wildlife Management 50 (1986), pp. 348–353. url: https://api.semanticscholar.org/CorpusID:87689453.

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