Shorebird Behavior Analysis

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Introduction

In the context of this study, foraging refers to the particular behavior exhibited by a bird as it searches for food within an observable distance from the shore. When it comes to foraging in shore birds, it is already known that variations in morphological features of different species lead to differences in foraging behaviors (Thomas, 2006). According to a review published in 2006, shore birds forage by using their bills to poke around on soft turf in an effort to find food (Thomas). Bill morphology plays a crucial role in dictating the foraging habits of shore birds. Whether shore birds possess shorter bills, such as the larus, sandpiper, and terns, or longer bills, like the godwit and curlew, plays a role in the foraging rate. The same review also details the various other ways in which foraging habits may differ between species, such as the optimal time of day for foraging, body mass and metabolic needs, the cycle of the tide, as well as visual capabilities due to characteristics like eye size. For example, the willet, a species that we observed during the duration of our study, tends to possess more nocturnal foraging behaviors. Another study conducted by the Percy Fitzpatrick Institute of African Ornithology in 1979 focuses specifically on the potential relationship between foraging habits of the curlew and shore level.

The questions that this study explores regard the foraging rate of shore birds and the factors that may influence it. The first research question that we attempt to answer is as follows: Does foraging rate differ between the different species of shore birds? We hypothesize that foraging rate does differ between different species of shore birds. We expect to see habitual and physical differences between different species of birds, which will in turn affect foraging rate. Another question that we aim to answer is whether or not foraging rate differs along the high tide line due to food availability. Our hypothesis states that foraging rate does differ along the high tide line as a function of food availability. We predict that foraging rates will increase as food availability increases, as more food abundance in turn creates more foraging opportunities. Lastly, we are also investigating whether or not foraging rate differs between species of birds with long and short bills. Our hypothesis is that foraging rate will differ between species of birds with long and short bills. We predict that birds with longer bills will exhibit higher foraging rates, as a longer bill is more efficient than a shorter bill for foraging. We expect that our results

will show significant differences in foraging rates due to discrepancies within these differences that therefore either increase or decrease foraging efficiency.

Methods

The BIEB research team conducted observations from many San Diego beaches inhabited by shore birds between 2022-2024. To first estimate the distance from the high tide line, each person measured their stride count for 10 meters by walking a tape measure of 20 meters and dividing by 2. We defined steps as putting one foot in front of the other, with "left right left right" being 4 steps total. We observed six geographical zones of the La Jolla Shores beach, each for 15 minutes before moving to the next zone. When arriving at a zone, we first took a point count by recording the total number of birds in that zone. The bird species included calidris, godwit, numenius, willet, larus, and plover. We individually observed a selected bird for up to 1 minute, counting each foraging behavior conducted by the bird and recording it on paper. Foraging behavior included any time a bird's bill made contact with the ground. We worked in pairs with one person being the observer and the other being the timer. While observing, we maintained at least a 20 meter distance from the bird. If the bird was no longer visible during the observing period, we stopped the observation at the time the bird went out of view. We then estimated the distance from the high tide line by walking the distance from the bird to the high tide line. Each person made 7-8 observations total, all between 10-60 seconds each, and inputted this data into a spreadsheet.

To assess the effect of species and distance to high tide line on the foraging rate of shore birds, we ran a General Linear Model in RStudio. We used the routine lm(), with foraging rate as our dependent variable. We added species, distance to high tide line, and the interaction between these two factors as our independent factors. We predicted that the effect of distance on foraging rate would be significant and positive overall, meaning the foraging rate would increase as birds are closer to the water. We predicted that the effect of species on foraging rate would be significant and negative, meaning that as species size decreases, the foraging rate would increase. Lastly, we predicted that the interaction between distance to high tide line and species would be significant, as some species may have negative or no relationship between distance to high tide line and foraging rate. To assess the effect of body mass and bill morphology on the foraging rate of shore birds, we ran another General Linear Model. We used the routine lm(), with foraging

rate as our dependent variable and body mass and bill morphology as our independent variables. We predicted that the effect of bill morphology on foraging rate would be significant and positive, meaning as bill length increases, foraging rate also increases. Lastly, we predicted that the effect of body mass on foraging rate would be significant and negative, meaning as body mass increases, foraging rate decreases.

To visualize the data, we also added bar charts and scatter plots using ggplot2 and sciplot in R Studio. The bar charts compared multiple features of a variable, such as the different bird species or different bird beak lengths. The scatterplots showed possible correlation between two variables, such as foraging rate and distance to high tide line.

Results

The rate of foraging did not significantly increase with an increased distance from the high tide line preventing us from rejecting the null hypothesis ($F_{1,2690} = 0.148$, $P = 0.70$, Fig. 3). Foraging rates for smaller species, e.g. willets, are significantly higher compared to larger species, e.g. lari, allowing us to reject the null ($F_{6,2690}=124.1464$, $P < 0.001$, Fig. 3). The difference between species and their foraging rate is visualized in figure 1 with smaller species having a higher foraging rate than larger species. When the distance from the high tide line increased there was an increase in foraging rate for species with long beaks, e.g. godwit, while species with short beaks, e.g. lari, did not ($F_{6,2690} = 2.8918$, $p < 0.01$, Fig. 3 and Fig. 2).

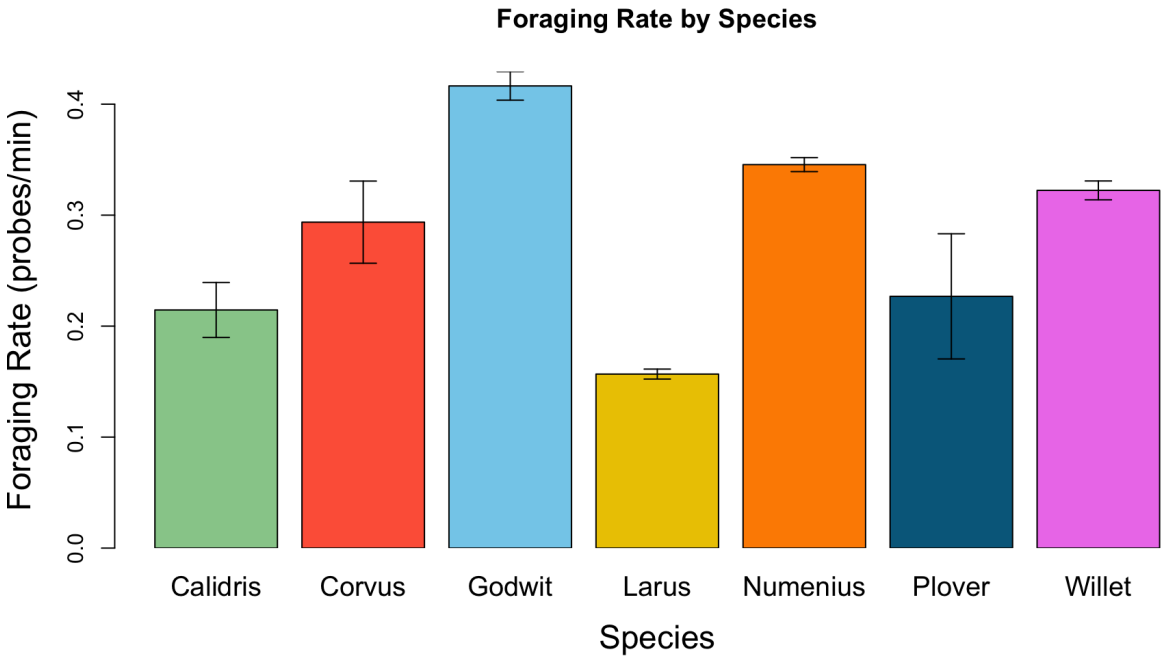

Fig. 1 Species is the independent variable and foraging rate is the dependent variable. Each bar indicates a different species with the corresponding label below it.

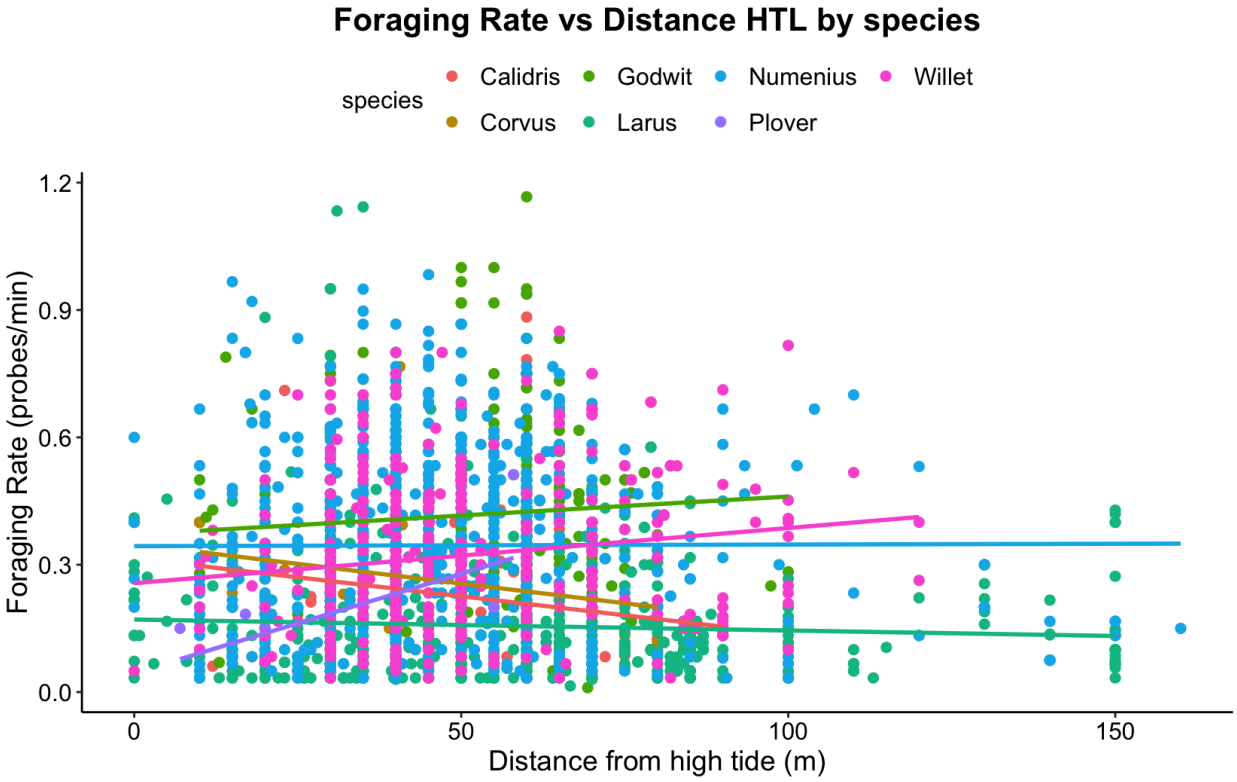

Fig. 2 The scatter plot displays the change in foraging rate (independent variable) with a change in distance from the high tide line (dependent variable). Each species is indicated by a different color seen in the legend.

	F	**df**	**P**
DistanceHTL	0.148	1, 2690	0.70
Species	124	6, 2690	<0.001
DistanceHTL*Species	2.89	6, 2690	0.0082

Fig. 3 The F value, P value, and degrees of freedom calculated by an ANOVA test in R for research questions 1, 2, and 3.

When analyzing bill morphology, species with longer beaks, e.g. godwit, foraged at a higher rate than those will shorter beaks, e.g. lari, and we can reject the null hypothesis ($F_{2,2698} = 328.8285$, $p < 0.001$, Fig. 4. Those with long and medium beaks have a significantly higher foraging rate than those with short beaks (Fig. 5). When average body mass increases, foraging rate decreases and the null hypothesis is rejected ($F_{1,2700} = 300.6865$, $p < 0.001$, Fig. 6 and Fig. 7).

	F	**df**	**P**
DistanceHTL	0.0368	1, 2698	0.85
Bill Morphology	329	2, 2698	<0.001

Fig. 4 The values for degrees of freedom, F, and P were calculated using an ANOVA test in R for research question 4.

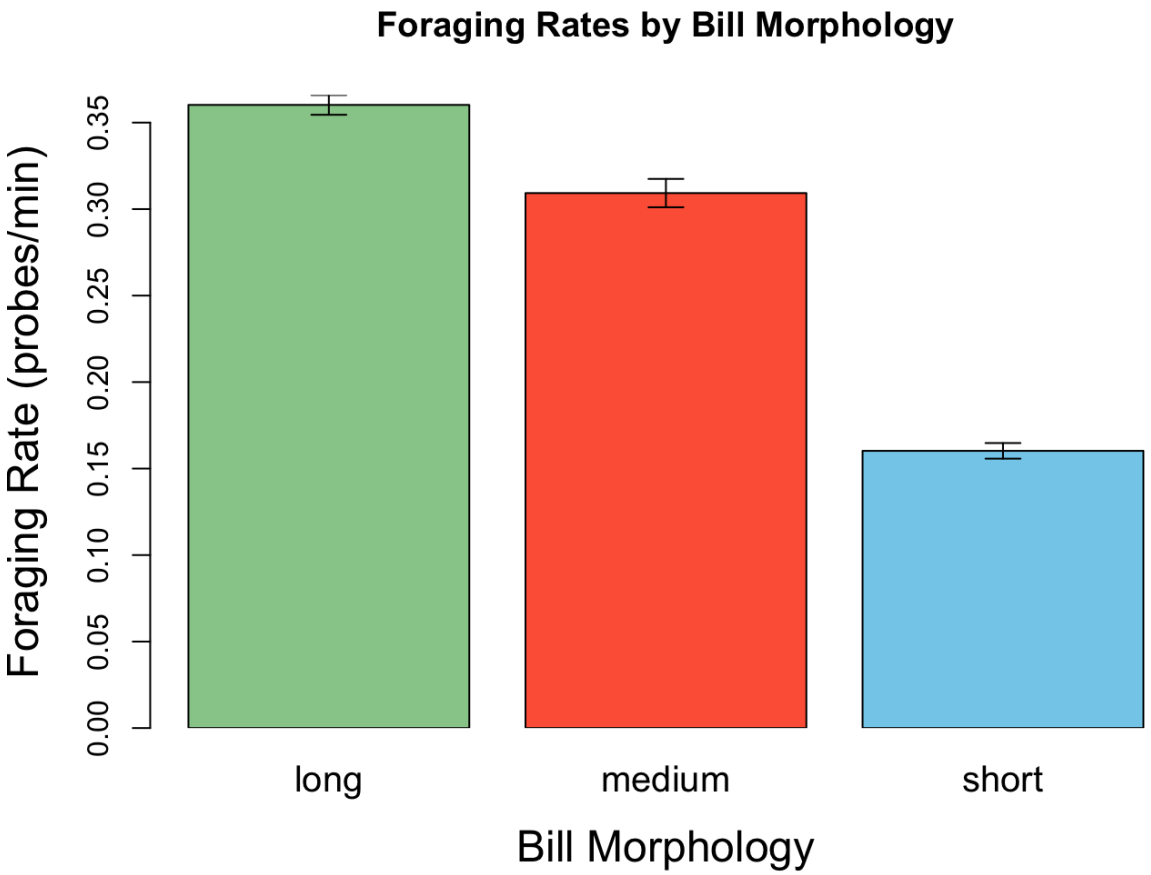

Fig. 5 Long (green), medium (red), and short (blue) bill length (independent variable) are shown in comparison to their foraging rate (dependent variable).

	F	**df**	**P**
DistanceHTL	3.59	1, 2700	0.058
Average Body Mass (g)	300	1, 2700	<0.001

Fig. 6 The ANOVA values calculated using R are shown for research question 5.

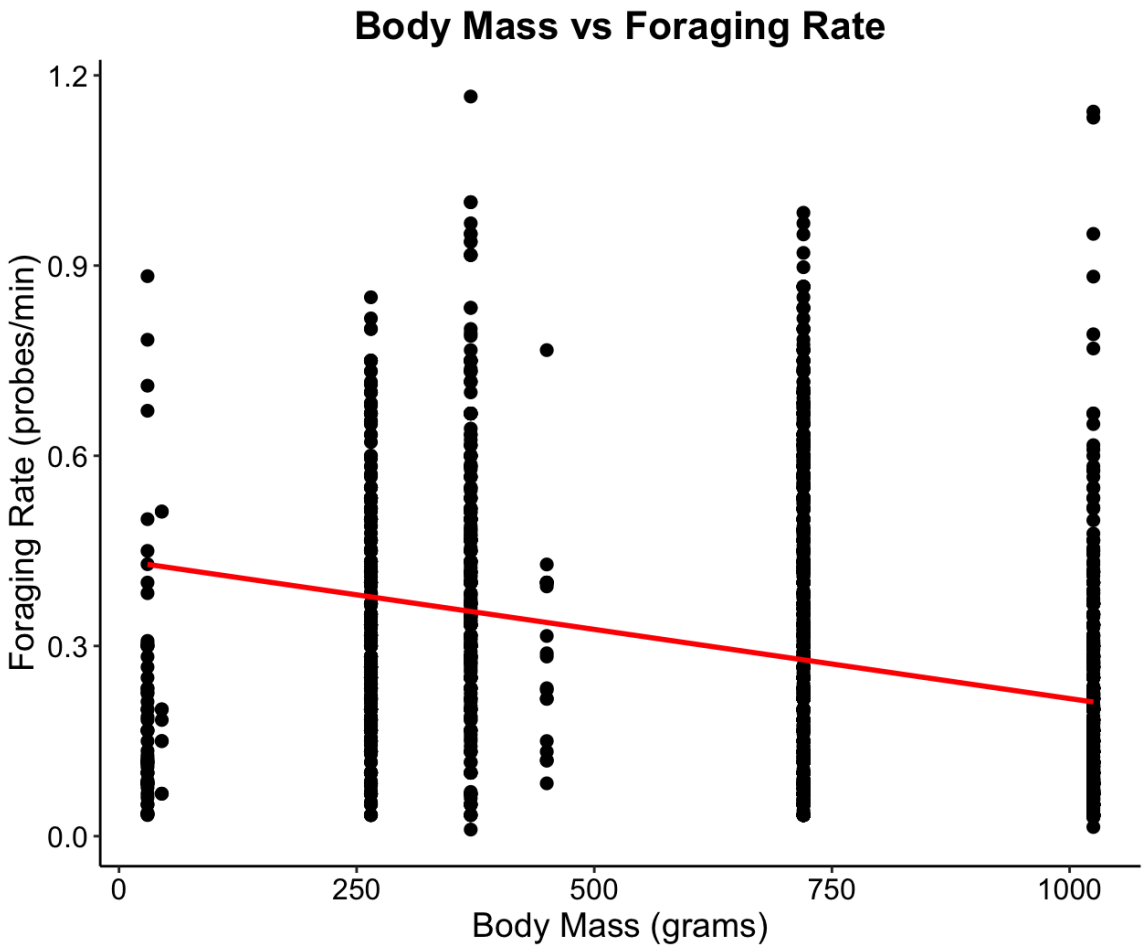

Fig. 7 Body mass is the independent variable while foraging rate is the dependent variable. The trendline in red shows the relationship between body mass and foraging rate.

Discussion

The goal of our research was to compare the morphological features of different shorebirds to their foraging behavior, and we constructed multiple hypotheses to do so. Firstly, we hypothesized that different species forage at different rates, with smaller species foraging at higher rates because of their higher metabolic activity. We noticed that small species, like willets, foraged at higher levels than larger species, like lari, which supports our hypothesis. In addition, we hypothesized that some species would forage at higher rates with increasing distance from the high tide line, potentially due to differences in the species preference for the wet sand farther from the high tide line. Our data suggested that some birds, like willets and

plovers, foraged at higher rates as distance from the high tide line increased, while others species did not change their foraging rates. This supports our original hypothesis. Furthermore, we hypothesized that foraging rates would be higher for long-billed species, because long bills are less efficient for finding food. Our data again supports this hypothesis, because long-billed birds have the highest foraging rates. Lastly, we hypothesized that body mass would be inversely related to foraging rate, because large birds have lower metabolic demands and require less food. Our data suggests that large birds, like lari, had lower foraging rates than small birds, like willets, which again confirms our hypothesis.

On the other hand, one of our hypotheses was that birds would have higher foraging rates as their distance from the high tide line increased, because more food would be available closer to the water line. However, our data did not show any significant difference in bird foraging rates as distance from the high tide line increased, refuting our original hypothesis. One limitation to our study was that the BIEB team's observations were made on heavily populated beaches, and although we made sure not to disturb the birds, other beachgoers did not. Therefore, many birds stayed closer to the high tide line and away from beachgoers, making it hard to determine the true relationship between foraging activity and distance to the high tide line.

Foraging patterns in different shorebirds have been studied in depth by other researchers, and the morphological advantages of different species clearly elucidated. For example, scientists have observed that birds with longer bills are able to probe deeper into the sand and find larger prey, allowing them to forage less often (Norazlimi, 2015). This finding contradicts our observation that long-billed birds have increased foraging rates, and our observations could be due to another underlying factor affecting foraging rate. However, this would require further investigation. Other scientists have also observed that the larger species also spend less time foraging, which we noticed as well (Ntiamoa-Baidu, 2008). Considering the discrepancies in foraging behavior noted between scientists, there is still much to be learned about the foraging habits of shorebirds.

References

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