

**Vegetation Structure Effect on Bird Foraging Behavior Across the Summer Season in
Montane Wet-Meadows**

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Abstract

Mountain White-crowned Sparrows and Wilson's Warblers rely on foraging microhabitats in montane wet meadows during the breeding season to find food for themselves and their offspring. The microhabitats are comprised of vegetation, which can be food itself, but it can also be a substrate for invertebrates that birds can consume. I investigated the differences in foraging microhabitat vegetation structure between these two species by conducting foraging observations accompanied by vegetative surveys. Observations took place in two survey periods to account for food availability and breeding season interferences: late June to early July and mid-July to late July. I found that vegetative structure had no significant effect on foraging efficiency. Additionally, neither bird was found to be significantly more efficient at foraging. I found that the two target birds forage significantly more efficiently later in the season.

Introduction

During the summer, a top priority for montane breeding birds is to forage for themselves and their nestlings. Prey availability and parental foraging success are crucial to the survival of nestlings, as they are unable to obtain food themselves (Gawlik, 2002). Montane wet-meadow biomes contain a variety of breeding birds, all of which share the same macrohabitat, resulting in a competitive breeding season, where they must all forage for themselves and their prospective nestlings. Many species of breeding birds in this macrohabitat have overlapping diets, primarily consisting of terrestrial invertebrates, which are especially nutritious for developing nestlings (Echeverri, 2024). Niche partitioning is crucial for species coexistence in these macrohabitats because of overlapping diets; it is even more important for the species that have shared microhabitats within the montane wet-meadows (Wiens and Rotenberry, 1979; Cabral Eterovick & Souza Barros, 2003).

In montane wet meadows surrounding Gothic, Colorado, Mountain White-crowned Sparrow (*Zonotrichia leucophrys* ssp. *oriantha*) and Wilson's Warbler (*Cardellina pusilla*) are two common species of breeding birds that migrate from Canada to Central America (Chilton et al., 1995; Ammon and Gilbert, 1991). Mountain White-crowned Sparrows consume mostly seeds, with invertebrates making up a small portion of the adult diet and the primary portion of the nestling diet (Chilton et al., 2020). Meanwhile, Wilson's Warblers primarily consume insects, with seeds and fruits accounting for a small portion of the adult diet (Ammon & Gilbert, 2020). Both species breed only once during the summer months, with breeding season only altering the dietary composition of the Mountain White-crowned Sparrow. While these birds occupy the same macrohabitats, montane willow thickets and wet meadows, little is known about how they may partition foraging efforts and whether the microhabitats used are structurally similar (Chilton et al., 1995; Ammon and Gilbert, 1991). A 1980 study suggests that White-crowned Sparrows might alter their microhabitats based on heat regulation, but there were no published observations on how this affected their foraging and diets (DeWoskin, 1980).

An important component of acquiring sufficient food, both to feed nestlings and themselves, is the foraging efficiency of the adult bird. Foraging efficiency, which can be measured through observations, is used to understand and quantify how successful a bird is at food acquisition (Hutto, 1988). My objective was to use this method to compare Mountain White-crowned Sparrows and Wilson's Warblers' foraging behaviors in montane wet meadow macrohabitats and quantify their foraging efficiencies, type of food item, and the vegetation structure of the foraging microhabitat, to understand their specific partitioned niche. I predict they will need different microhabitats for foraging because of their overarching dietary

differences. Therefore, I can contrast the impacts of vegetation structure for two different foraging strategies.

Methodology

This study used the sites previously established by Dr. Savannah Troy for her avian phenological research. I conducted foraging observations and vegetation structure surveys in areas surrounding all fifteen of her sites, which are spaced at least 350 meters away from each other throughout montane wet meadow habitats. The only materials used for the data collection were binoculars, flags, and a voice recording device to log the interactions observed.

I conducted foraging observations by randomly walking around a study site, scanning for target birds. When I spotted one of the target birds, I watched from a distance to limit detection, until the bird foraged. Once there was a foraging attempt, I watched the bird until it was lost, or until five minutes passed, per Holmes and Robinson (1988). I used the voice recorder to verbally specify the species of bird, the height of the bird off the ground, each instance when a bird caught and consumed a food item, and, if possible, the type of food item. Following a foraging observation, I marked the exact spot where the bird was when it foraged with a flag. The substrate on which the bird foraged was also recorded. Then, I conducted a vegetation structure survey, recording proportional ground cover of herbaceous plants (including wildflowers), woody shrubs, trees, grasses, and bare ground within a one-meter radius. Next, I recorded the proportional cover of woody shrubs within a five-meter radius circle and the maximum height of the shrubs. Next, I logged the number of trees within a ten-meter radius circle. Lastly, I noted the approximate distance of the forage site to the road. This method was based on standard practice for bird habitat structure surveys (Conway and Martin, 2000). This technique was repeated with each bird observed, without re-recording the same individual of the same species within a single

site. This was done by recording either one male and one female of the Wilson's Warbler or, in the case of the Mountain White-crowned Sparrow, traveling at least 250 meters away from the first bird.

This procedure was repeated twice throughout the Summer of 2025: Survey One lasted between June 30th to July 15th, and Survey Two lasted between July 18th to July 29th. This was done to account for summer plant growth, the progression of bird breeding, and weather changes.

Data Analysis

For the data analysis, I ran a beta-distributed generalized linear mixed model (GLMM) where foraging rate (number of forages divided by the time observed) was the response variable predicted by: bare ground percent coverage, woody shrub coverage within five meters, time of year, and species difference. I used a random effect of site identity to account for the possibility that I resurveyed the same individuals between surveys 1 and 2. The former two predictors were chosen to test the data on vegetative coverage and microhabitat usage; the latter two were chosen to test the data on behavior observed, which is how this results section will be divided. For the first three tests, it is important to note that the two species were combined for the analysis. The overall analysis, including estimates, standard errors, and p-values, can be seen in Table 1. I interpret significance based on model results with a $p\text{-value} < 0.05$.

Results

I observed 39 birds, 12 Wilson's Warblers and 29 Mountain White-crowned Sparrows. The average duration of observation for both species was two minutes and forty-four seconds. The average duration of observation for Wilson's Warblers was one minute and forty-two seconds, and the Mountain White-crowned Sparrow's was two minutes and forty-five seconds. The average rate of forage for Wilson's Warblers is 0.0147, and the average rate of forage for

Mountain White-crowned Sparrows is 0.0121. There were four instances of grain foraging, all from Mountain White-Crowned Sparrows; the rest of the forages were all on terrestrial arthropods.

The average vegetative coverage of each classification is as follows: 13.09% herbaceous, 17.13% bare ground, 11.54% tree, 44.74% woody shrub, and 13.50% grasses. The average percentage of woody shrubs within a five-meter radius was 50.00%. The average number of trees within a ten-meter radius was 5.83 trees. The average distance from the road was 62.50 meters.

Vegetation structure

The generalized linear mixed model tested for significance for both bare ground (*Fig. 1*) and woody shrubs within a five-meter radius (*Fig. 2*). Bare ground was not a significant predictor when plotted against foraging rate with a p-value of 0.286. Woody shrubs within a five-meter radius also was a nonsignificant predictor when plotted against foraging rate with a p-value of 0.213.

Behavior

The generalized linear mixed model tested for significance for both calendar date (*Fig. 3*) and species difference (*Fig. 4*). Calendar date was a significant predictor when plotted against foraging rate with a p-value of .001. Species difference was not a significant predictor when plotted against foraging rate with a p-value of 1.26.

Discussion

Throughout all of the vegetation surveys, I found that there was no significant difference in the microhabitats used by the two different species. Microhabitats composed of woody shrub usage, which was expected to have a great difference per the literature, came back with only a slight difference (P-value = 0.213). This might be a result of low sample size, but, more likely,

this can be explained through the tight growing season and high competition of birds in the montane wet-meadows (MacKinnon and Freedman, 1993). Either way, a higher sample size would help this statistic. The bare ground usage had little difference between the Mountain White-crowned Sparrow and the Wilson's Warbler, henceforth referred to as MWCS and WIWA, respectively. The literature suggested MWCS would have a higher usage of bare ground, and while this appears to be reflected in this study, the data is not significant ($P\text{-value} = 0.286$).

Climate change is rapidly altering prey availability through earlier vegetation growth and earlier insect emergence (Gonzalez et al., 2010, and Martinat, 1987). Additionally, climate change causes earlier snowmelt, affecting yet another discrepancy in food availability (Stanton et al., 1994). These factors affect the timing and duration of breeding periods (Santangeli & Lehikoinen, 2017), the vegetative structure of microhabitats used by birds (Kissling et al., 2010), and the timing of optimal food resources (Parmesan, 2006). This study found a significant trend for both target birds foraging more later in the summer season, rather than earlier. This trend, impacted by climate change, is not well explored, but there are two leading hypotheses. The most noted hypothesis is that towards the end of the summer, as the mean temperature of each day decreases, the energetic demand pressures birds to collect more energy and food storage to prepare for migration (Bonter et al., 2013; Lovette and Holmes, 1995). The other notable hypothesis is that, specifically, MWCS due to their mixed diets, have more food availability later in the summer due to plants which produce edible seeds, buds, and flowers (Lemke, 1984). I observed one instance of grain foraging in Survey One and three in Survey Two, which anecdotally suggests the latter hypothesis. Moreover, based on personal observations of the field sites, berry-bearing bushes were seen to have bloomed later in the summer. Additionally, *Ligusticum porteri*, was foraged on in Survey Two, whereas it was not in blooming during

Season One. It is very likely that these two hypothesis are both true and affecting these birds simultaneously. Additionally, the completion of breeding season for both target birds might have played a part in this significance: post-breeding season, after all the nestlings fledge, results in the birds having more opportunity to feed for themselves and spend less time on parental care (Rudolph, 1982; Wesolowski, 1994). This theory is likely to have played a part in this study because Survey Two took place post-breeding.

Wilson's Warblers were observed to forage slightly more frequently within the observation period ($P\text{-value} = 0.126$). It is important to note that sample size might have played a role in this factor, as there were more MWCS observed, lending the individual WIWA more statistical weight ($n = 27$ MWCS, $n = 12$ WIWA). If this is not the case, however, it is believed that warblers are better adapted for specialized insectivorous gleaning, which is much quicker than the MWCS generalized mixed-diet feeding (Ammon and Gilbert, 1991; Korpimäki et al., 2020). All WIWA in this study exclusively gleaned, whereas MWCS gleaned and foraged on the ground for seeds. This more diverse diet, while beneficial in some ways, is predicted to have a tradeoff in foraging skills, making the MWCS less efficient at foraging succinctly (Korpimäki et al., 2020; Recher, 1990). More testing would be required to understand this fully.

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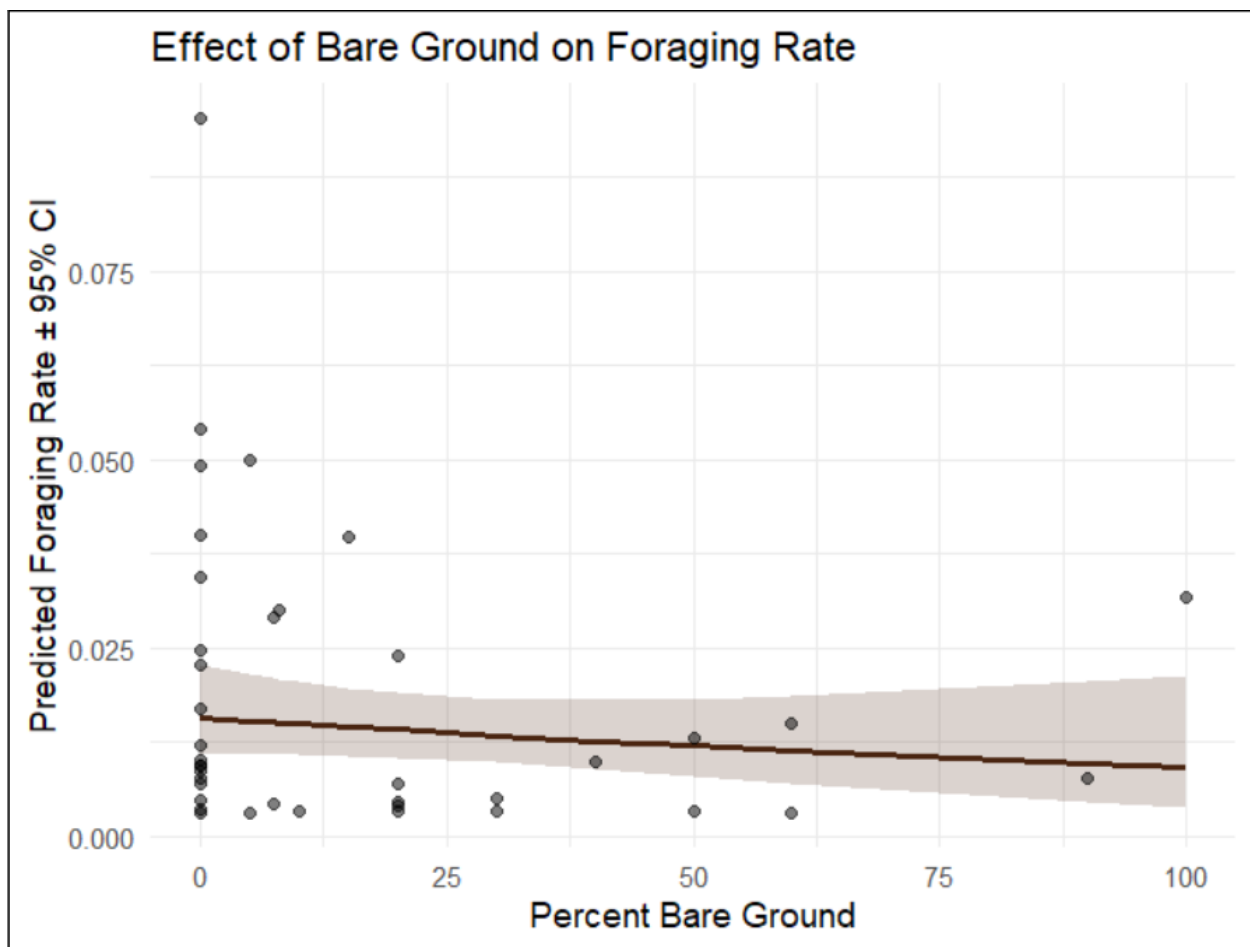


Table 1: Summary of beta-distributed GLMM predicting foraging rate against bare ground percentage. Significance interpreted based on predictor p -values being < 0.05 . The dots represent the raw data, the line represents the generated prediction and line of best fit, and the ribbon represents the 95% confidence interval.

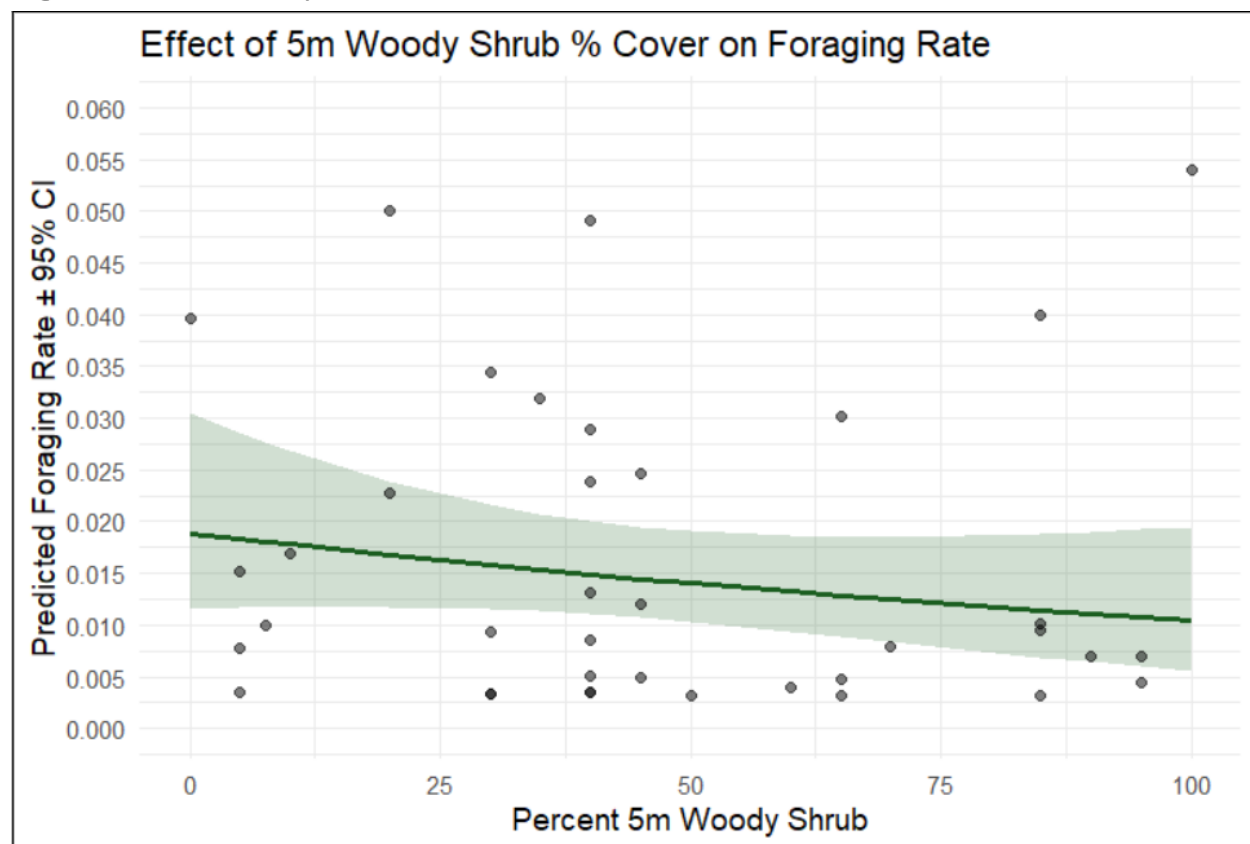


Table 2: Summary of beta-distributed GLMM predicting foraging rate against five-meter woody shrub cover. Significance interpreted based on predictor p -values being < 0.05 . The dots represent the raw data, the line represents the generated prediction and line of best fit, and the ribbon represents the 95% confidence interval.

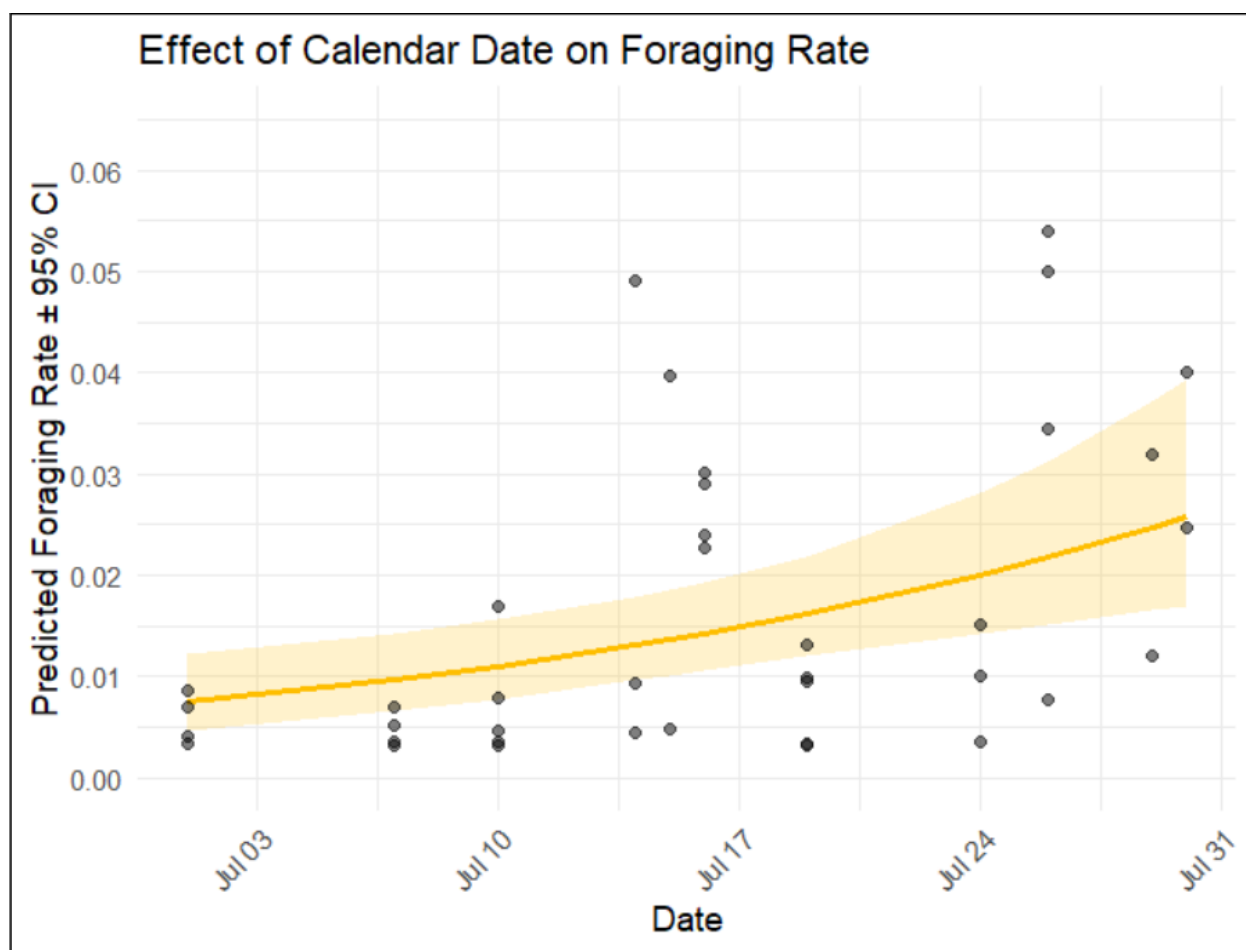


Table 3: Summary of beta-distributed GLMM predicting foraging rate against calendar day. Significance interpreted based on predictor p -values being < 0.05 . The dots represent the raw data, the line represents the generated prediction and line of best fit, and the ribbon represents the 95% confidence interval.

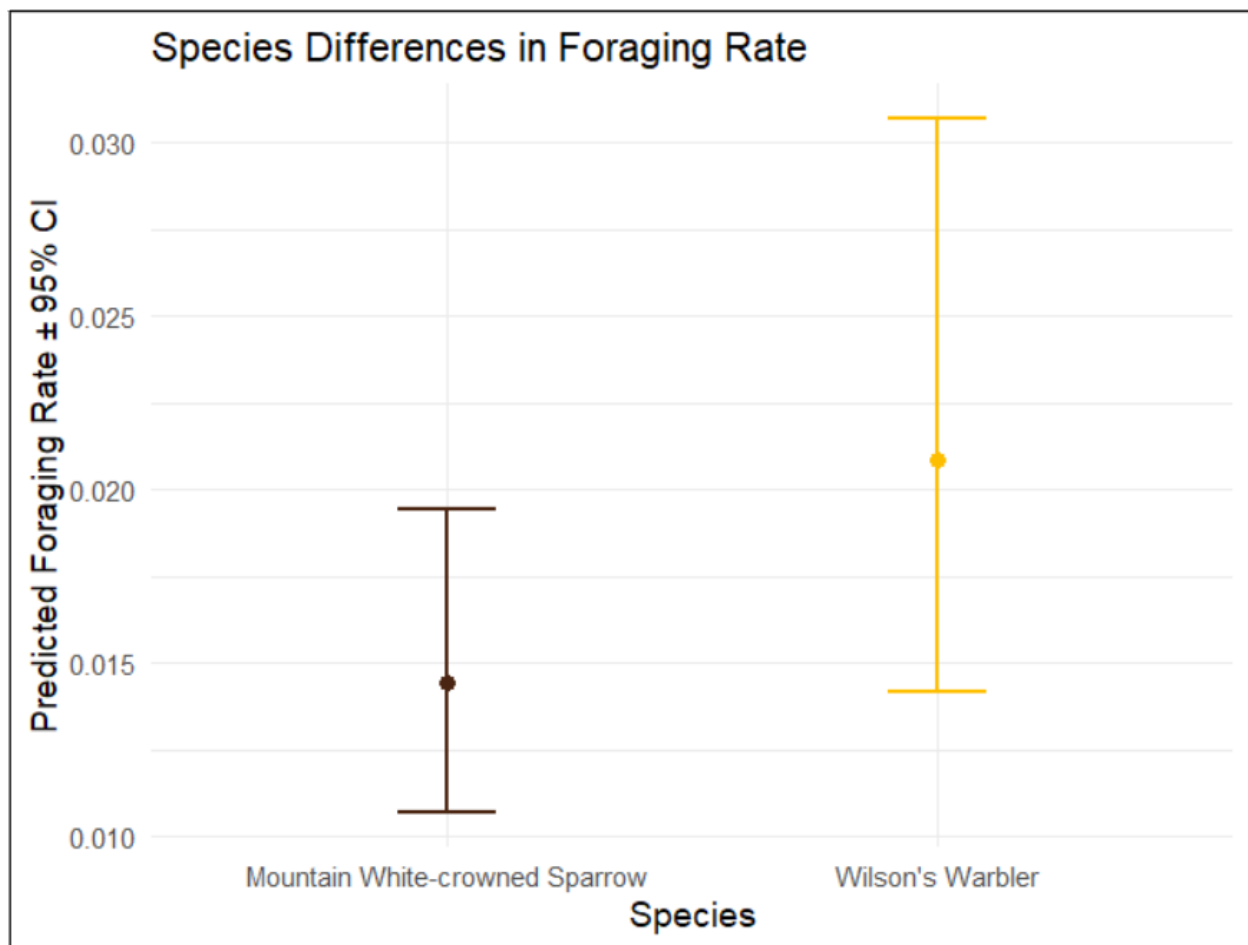


Table 4: Summary of beta-distributed GLMM predicting foraging rate against species. Significance interpreted based on predictor p -values being < 0.05 . The dots represents the mean foraging rate per species, and the vertical lines represent the 95% confidence interval, with the top and bottom bars depicting the upper and lower confidence limits, respectively. The Y axis is the number of forages per minute, and the X axis shows the two target species.