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Analysis of upland and riparian stopover sites for migrating songbirds in Central Texas

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Introduction and Rationale

Migration is the period of greatest mortality throughout a migratory songbirds' annual cycle and has profound effects on breeding success and survivorship. High-quality stopover sites, with abundant food resources, allow for rapid refueling of energy stores enabling a songbird to continue the next portion of its journey. Identifying where high-quality stopover sites are located along migratory pathways, and how habitat characteristics affect the physiological condition of migratory birds has implications for the conservation of these species. Riparian areas are recognized as important stopover habitats, particularly in the desert Southwest, whereas upland habitats provide adequate stopover sites in other regions of North America, such as the Midwest. Central Texas lies squarely in the Central Flyway, yet no research to date has investigated stopover habitat in this region. In light of recent avian population declines, it is imperative to study migratory birds' full annual cycle, including the migration period. Identifying high-quality habitat important for songbirds at stopover sites in Central Texas will allow conservation practitioners with limited resources to prioritize areas for land acquisition or direct management land actions optimal for migratory songbirds.

The objective of our research is to provide a comprehensive analysis of relative habitat quality of riparian and upland areas for small songbirds migrating through the Edwards Plateau of Central Texas. The research will be presented in three chapters addressing 1) the physiological state of songbirds at stopover sites, 2) migrating songbird abundance in regard to habitat characteristics, and 3) prey availability (arthropod abundance). Refueling rates and chronic stress levels assessed through plasma metabolite profiling and H/L ratios reflect the physiological condition of songbirds at stopover sites. Given that habitat quality has direct effects on the physiological state of individuals, Chapter 1 will provide a comparison of riparian and upland habitats on the ability of birds to replenish their energy stores. We will also examine the relationship of body condition indices of migrating birds between habitat types and year. In Chapter 2, a habitat analysis of stopover sites will be conducted using remote sensing and field techniques to identify fine-scale habitat variables that are important to migrating birds using stopover sites in Central Texas. Additionally, we will develop predictive models to assess whether NDVI values, a proxy for vegetation productivity, are strong indicators of high-quality habitat. Lastly, in Chapter 3, we propose to compare prey availability (arthropods) for migrating songbirds between habitat types.

We hypothesized that migratory birds will be in better physiological condition and have higher refueling rates in riparian stopover sites compared to upland sites (Chapter 1). We also predict that migrating songbird abundance will be greater in riparian areas due to the presence of habitat characteristics that are historically correlated with greater bird abundance. Finally, we hypothesize that arthropod availability will be greater in riparian areas than in upland areas.

Methods

Physiological condition: *body condition, refueling performance, and chronic stress evaluation*
Data Collection (data collection may extend into spring 2024) – Using mist nets, we captured migrating birds from 15 March to 15 May in 2022 and 2023. Blood samples were collected to perform plasma metabolite profiling of triglycerides which may be used as a proxy for refuleing performance and habitat quality. The remainder of the samples were used to prepare blood smears for chronic stress analysis (heterophil/lymphocyte ratio counts). Linear mixed models will be used to test for differences in metabolites (TRIG) and H/L ratios between habitat types.

Fine-scale habitat characteristics and bird abundance - To identify habitat characteristics affecting migrating songbird abundance at stopover sites, a combination of point count surveys and remote sensing techniques will be used. Point count surveys were conducted during spring migration in 2022 and 2023. NDVI (Normalized Difference Vegetation Index (NDVI) will be used to examine habitat productivity and Global Ecosystems Dynamics Investigation (GEDI) will be used to characterize vegetation structure in riparian and upland habitats. For statistical analysis we will use a generalized linear regression for categorical analysis of Poisson count data to compare migratory songbird abundance between habitats and linear mixed models to further examine habitat characteristics important for migrating songbirds.

Arthropod abundance – Data collection in April and May 2023. To examine habitat differences in arthropod availability, we used the beat sheet method to estimate lepidoptera larvae biomass. In addition, sticky traps were deployed within the point count survey area to access flying arthropod abundance. For statistical analysis we will use a series of ANOVAs in a nested structure to analyze caterpillar biomass, flying arthropod abundance, date, and habitat type to explore food available for songbirds.

Preliminary results

A total of 82 blood samples were successfully collected for plasma metabolite analysis (n=29 in 2022 and n=53 in 2023). When comparing plasma metabolites between years, TRIG concentrations were significantly higher in 2023 than in 2022 (t (68 = -7.55, p=<0001) (Figure 4). When examining plasma TRIG concentrations within each year, TRIG concentrations were statistically similar between upland and riparian habitats for migratory birds in 2022 (t (24)= -0.711, p= 0.484). The mean TRIG concentration for riparian sites in 2022 was 0.498 ± 0.09 (SE) and 0.654 ± 0.22 in upland sites. However, TRIG concentrations were significantly higher for

riparian habitats than in upland habitats in 2023. The mean TRIG concentration in riparian sites in 2023 was 2.187 ± 0.27 (SE) and 1.515 ± 0.16 in upland sites.

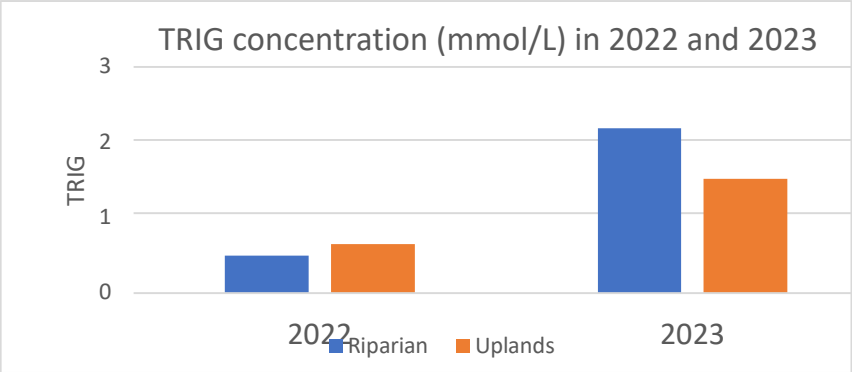

Figure 4. Plasma triglyceride concentrations (mmol/L) for upland and riparian sites in 2022 and 2023.

Of the taxa sampled for both years, TRIG concentration was markedly higher for thrushes (2.65 mmol/L) than other species and lowest for tanagers (0.322 mmol/L). (Figure 5).

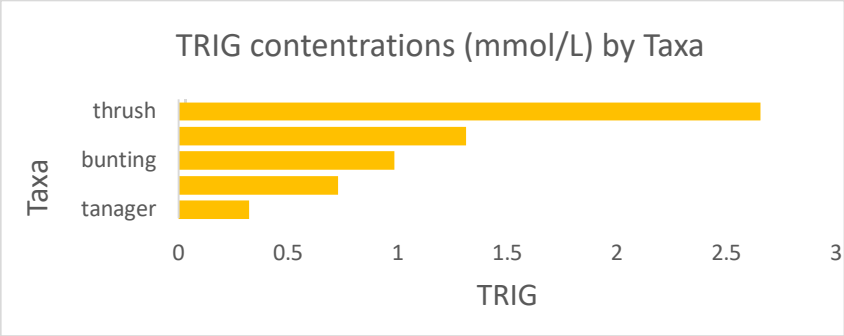

Figure 5. Plasma triglyceride concentrations (mmol/L) by taxa in 2022 and 2023.

TRIG concentrations were not uniform across study sites. Overall concentrations were highest at Hamilton Pool Preserve and lowest at Wild Basin Preserve (Figure 6).

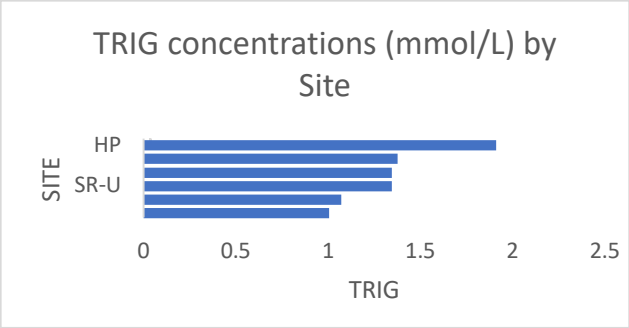

Figure 6. Plasma triglyceride concentrations (mmol/L) by site in 2022 and 2023.

Discussion

We hypothesized that riparian stopover habitat would provide better foraging opportunities for migrating songbirds allowing for higher refueling rates than upland habitats. Preliminary results suggest a more complicated interaction between year and habitat type than initially proposed. During spring migration 2022, refueling rates in the form of triglycerides (TRIG), were at extremely low concentrations when compared with previous studies in both riparian and upland habitats. Low refueling performance indicated poor habitat quality across all research sites and did not differ by habitat type (Cerasale and Guglielmo 2010, Smith 2013, Paxton and Moore 2017, Oberkircher and Pagano 2018). Refueling rates, however, were significantly higher in 2023 than in 2022 with riparian sites providing significantly higher TRIG concentrations than in upland sites.

The discrepancy between refueling performance across years may be a consequence of weather patterns. Precipitation rates during spring migration in 2022 were markedly lower (12.07 cm) when compared to precipitation rates in 2023 (25.70 cm) (National Weather Service, nd). The annual variation in rainfall may have affected available food sources such as arthropod abundance which are highly sensitive to changes in weather patterns such as precipitation amounts (Moller 2019, Rebaudo et al. 2016).

The interaction between year and habitat type may also be explained by annual variation in precipitation rates in 2022 and 2023. Although no statistical difference was found, refueling rates were slightly higher in upland habitats than riparian habitats in 2022. If low precipitation amounts affected food source abundance in both habitat types, competition may have influenced food sources if songbirds were more abundant in riparian habitats than in upland habitats. Cohen et al. (2022) found density dependent factors influenced refueling rates of migrating birds along the Gulf of Mexico. Competition among migrating songbirds at stopover sites deplete the food resources more readily in areas where they are present in high abundance. In turn, songbirds may not be able to procure sufficient fat reserves as reflected in low plasma triglyceride concentrations. More data analyses from Chapter 2 (comparison of migrating songbird abundance in riparian and upland habitats) are required to support the validity of this hypothesis.

Refueling rates may also differ by taxa. TRIG concentrations were highest for thrushes (2.65 mmol/L) and lowest for tanagers (0.32 mmol/L). However, tanagers were captured in 2022 only and low TRIG concentrations may be an effect of year rather than taxa.

When comparing overall refueling rates by study site, differences were found but not my habitat type. Hamilton Pool Preserve had the highest refueling rates; while, Wild Basin Preserve had the lowest refueling rates, both of which are riparian sites. However, more thrushes were captured at Hamilton Pool Preserve than other research sites and may have an effect on site refueling rates.

More statistical analyses are needed to explore influential variables and definitively identify habitats and characteristics that are important stopover sites for migrating songbirds in Central Texas. Previous studies suggest that variation of temperature and precipitation affect body condition of songbirds (McCloy et al. 2023) and annual variation of refueling performance of thrushes has been found at a long-term monitored stopover site in New York (Pagano et al. 2023). However, temperature and precipitation effects have not been examined in terms of refueling performance between different stopover habitat types. With the application of linear mixed models, we will fill knowledge gaps regarding the effects habitat type and weather patterns have on migrating songbirds in Central Texas.