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Janel Ortiz
California State Polytechnic University, Pomona

INFLUENCE OF BRUSH COVER AND ARTHROPODS ON AVIAN INSECTIVORES IN NATIVE RANGELANDS OF SOUTH TEXAS

Beatriz Martinez-Martin[1], Janel L. Ortiz[2,4], Andrea Montalvo[3]

[1]*Department of Biology, University of San Diego, San Diego, CA 92110*
[2]*Center for Excellence in Mathematics and Science Teaching, California State Polytechnic University-Pomona, Pomona, CA 91768*
[3]*East Foundation, San Antonio, TX 78216*

ABSTRACT.—Bewick's Wren (*Thryomanes bewickii*), Yellow-billed Cuckoo (*Coccyzus americanus*), Golden-fronted Woodpecker (*Melanerpes aurifrons*), Ladder-backed Woodpecker (*Picoides scalaris*), White-eyed Vireo (*Vireo griseus*), and Verdin (*Auriparus flaviceps*) are all residents of the South Texas landscape. While the species are unique in appearance, they share the diet of arthropods with each of these species categorized as an insectivore during the breeding season. During this time, they need more nutrients to keep up with the pressures of finding a suitable mate and maintaining their young. The objective of this study was to investigate the influence of brush cover and arthropods on avian insectivores in native rangelands of South Texas. It is important to look at relationships because it can help determine what is impacting bird abundance if populations are low. We established 600 m x 100 m line transects in two levels of brush cover (high [>50%] and low [<50%]). We placed pitfall traps at every 100 m along transects to capture arthropods utilizing ground habitat. We also used beatsheets and branch clippings at each pitfall site to sample arthropods living in shrubs and trees. Bird surveys were conducted once a week on transects and the focal bird species were recorded by visual and auditory means. Our results showed that there was a significant effect of brush cover level (high and low) and arthropod diversity on the relative abundance of avian insectivores. We observed a higher relative abundance of birds as arthropod diversity increased in high brush, and a lower relative abundance of birds as arthropod diversity increased in low brush. There were no significant effects of brush cover level and arthropod metrics on avian richness or diversity. Having a mosaic habitat with different canopy heights and diverse vegetation communities can positively influence animal populations and is important when considering land management strategies.

Avian insectivores consume arthropods as their main diet source; they are very common and are diverse in species which makes them essential to any ecosystem (Powell et al. 2015). Bewick's Wren (*Thryomanes bewickii*), Yellow-billed Cuckoo (*Coccyzus americanus*), Golden-fronted Woodpecker (*Melanerpes aurifrons*), Ladder-backed Woodpecker (*Picoides scalaris*), White-eyed Vireo (*Vireo griseus*), and Verdin (*Auriparus flaviceps*) are resident insectivores based on foraging guilds described by Graaf et al. (1985). These birds are classified as insectivores because their diet consists of 20% insects, either year-round or during the breeding period (Graaf et al. 1985). This has been further supported with results from fecal samples that have shown that Coleoptera, Hymenoptera, Orthoptera, Formicidae, and Arachnids are common prey for understory insectivores, making up about 75% of their individual diet (Şekercioḡlu et al. 2002). The substrate in which these birds hunt arthropods differs from species to species as some find their prey on the ground, shrub, bark, and/or canopy.

The Golden-fronted Woodpecker, Ladder-backed Woodpecker, and Bewick's Wren remain insectivorous year-round (Graaf et al.1985). Schroeder et al. (2013) found the diet of Golden-fronted and Ladder-backed Woodpeckers had a high percentage of animal matter, consisting of larvae and adult invertebrates. Ladder-backed Woodpeckers brought 100% of the animal matter to their nestlings with 99.5% being invertebrate

[4] E-mail: ortizjanel@gmail.com

larvae and only 0.5% being adult invertebrates. Golden-fronted Woodpeckers brought back 77.5%, yet with more invertebrate adults (56.3%), and fewer invertebrate larvae (21.2%) compared to the Ladder-backed Woodpecker, as well as 20.1% vegetation (Schroeder et al. 2013). The insects that the woodpeckers brought back were reflective of their foraging behavior (i.e., excavating and prying into bark). Yard et al. (2004) took stomach content samples from Bewick's Wrens which resulted in a variety of arthropods including Araneae, Hemiptera, Homoptera, Coleoptera, Diptera, Hymenoptera, Lepidoptera larvae, and other smaller samples with a higher proportion of Araneae. These orders are all reflective of an insectivore's diet and can all be found in the native rangelands of South Texas.

Arthropods are the most diverse group of animals and have the largest number of species in the world (Misof et al. 2014). The origin of insects has been dated back to derive from the Early Ordovician period, nearly 479 million years ago (Misof et al. 2014). Insects occur in almost any possible environment and play a crucial part of our ecosystem since they fulfill many roles ranging from decomposing organic matter to serving as food for fish and wildlife (Rosenberg et al. 1986). Due to the large abundance of insects practically everywhere in the world, it makes it rather easy to sample them and see the impact they make in both aquatic and terrestrial ecosystems as predators, prey, parasites, herbivores, among others (Rosenberg et al. 1986). Serving as prey, insects play a crucial role in the life cycles of many South Texas avian species, specifically insectivores that need protein year-round as well as during the breeding season for themselves and nestlings (Dhondt and Hochachka 2001).

Habitat and prey relationships of avian insectivores are important to their conservation and management, yet have not been fully explored in South Texas. The objective of our study was to determine the influence of brush cover level and arthropods on avian insectivores. We hypothesized that higher brush cover and higher relative abundance and diversity metrics of arthropods would yield a higher abundance and diversity metrics of birds. This was hypothesized because higher brush cover offers more protection and more resources benefitting both arthropods and insectivores. Having this information can provide further support in the precautions taken when considering land management practices used in ranching and wildlife conservation that may alter vegetation patterns that will impact arthropod and avian populations.

METHODS

Study Area

Our study occurred on the East Foundation's San Antonio Viejo Ranch (SAVR) from July to August 2019. The 60,000 ha ranch is in the southern plains of Texas in Jim Hogg and Starr counties located W of Hebbronville and N of Guerra. The SAVR is one of the 6 ranches operated by the East Foundation to promote land stewardship through ranching, science, and education. The ecological region of the area is characterized by coastal sand plain and Tamaulipan thornscrub with the general vegetation cover of honey mesquite (*Prosopis glandulosa*), grasslands, and shrubs (Omernik 1987). The average temperature at SAVR during the study was 33°C but had highs of 38°C and winds that ranged from 3-4 (6-20km/h) on the Beaufort scale.

Sampling Design

We sampled 8, 600 x 100 m transects located in the central part of the SAVR (Fig. 1). There were four transects located in each of two brush levels: 1) low brush cover (Fig. 2) and 2) high brush cover (Fig. 3) that were randomly assigned in ArcGIS 10.4 using a vegetation cover layer from the Texas Parks and Wildlife Landscape Ecology Program. We completed this by calculating the percent of brush in the area of the transects based on the vegetation layer. Brush cover for this study is defined as cacti, shrubs, and trees. Low brush transects had <50% of brush cover, whereas high brush transects had >50% brush cover.

Bird Surveys

Bird surveys were conducted twice per week with each transect surveyed once per week to ensure that all transects were completed before the heat of the day (approximately 1200 CST) when bird activity decreases. Transect visits were rotated and two transects per brush level were surveyed each day. On survey days, the vehicle was parked at least 50 m away from the starting point to avoid disturbing birds that may be inhabiting the location. At the start of the survey, environmental variables such as temperature, cloud coverage, and wind speed (Beaufort) were recorded using a Kestrel 2000.

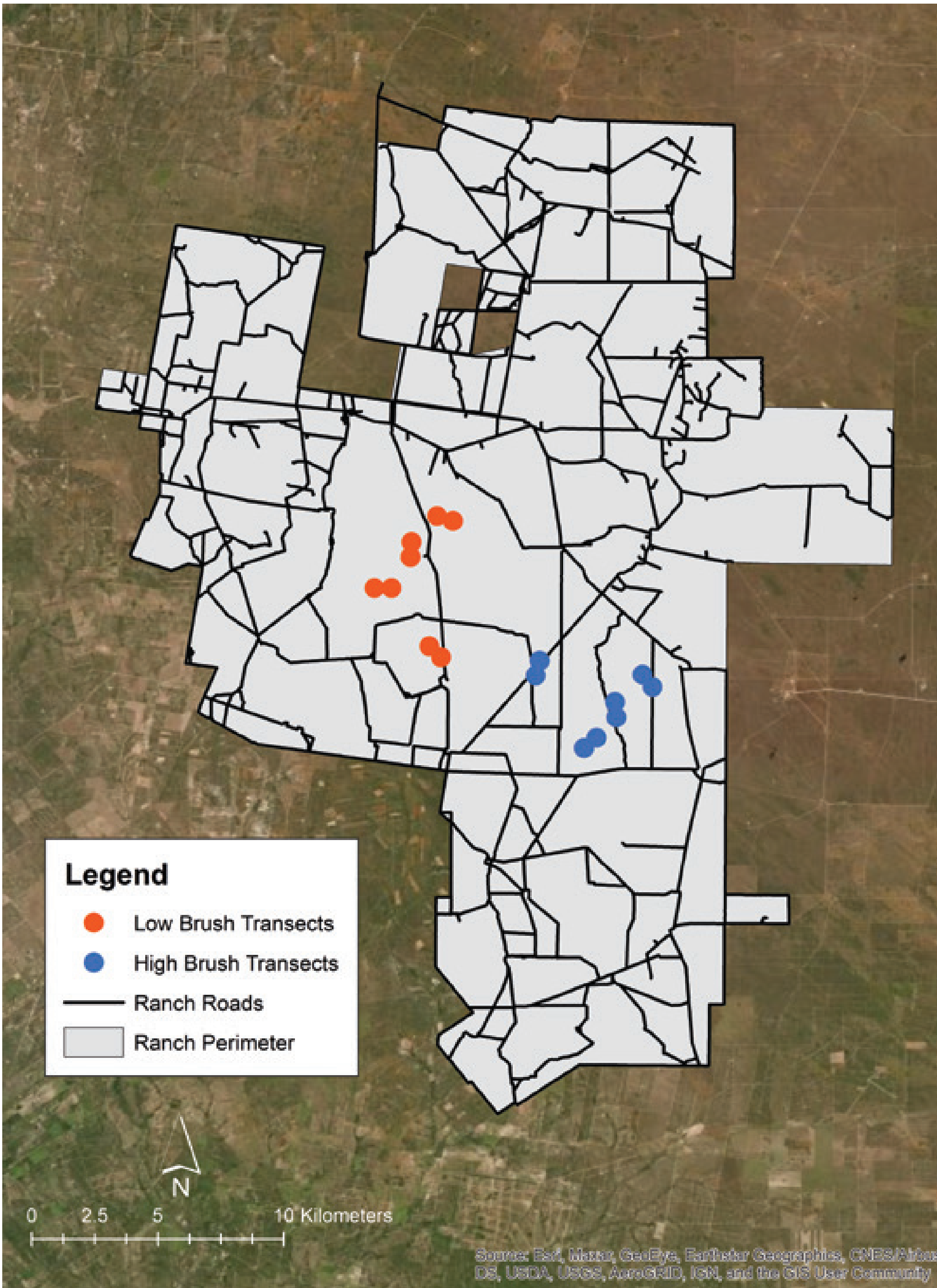

Figure 1. East Foundation's San Antonio Viejo Ranch in Jim Hogg and Starr counties, TX, USA. High (blue) and low (red) brush transects marked with circles indicating beginning and end of transects sampled from July-August 2019.

Figure 2. Example of vegetation found in a low brush (<50% brush cover) transect on the San Antonio Viejo Ranch, Jim Hogg and Starr counties, TX, USA in July-August 2019.

Figure 3. Example of vegetation found in a high brush (>50% brush cover) transect on the San Antonio Viejo Ranch, Jim Hogg and Starr counties, TX, USA in July-August 2019.

Surveys were performed by a single observer and all surveys began at sunrise with transects walked at the same pace while listening and observing for the focal species. The six focal species were year-round insectivores based on Graaf et al. (1985) and since we were at the end of the breeding season we also included breeding period insectivores. Focal species included: Bewick's Wren, Golden-fronted Woodpecker, Verdin, Ladder-backed Woodpecker, Yellow-billed Cuckoo, and White-eyed Vireo. No surveys were conducted with rainfall or winds with consistent ≥4 on the Beaufort scale.

Arthropod Sampling

We used three methods, accounting for the locations in which birds forage, to estimate arthropod populations:

1. Pitfall traps were set up at every 100 m along the transect (6 per transect) and sampled twice throughout the study period for one week.
2. Beatsheets were sampled at the nearest shrub to the pitfall trap and within 50 m of the transect and sampled twice throughout the study period.
3. Branch clippings taken from three different trees near each pitfall trap, each from a different height of the canopy (low canopy, center canopy, upper canopy) within 50 m of the transect and were sampled twice throughout the study period.

For pitfall traps, we used 16 garden staples, a plastic cup (9 oz), plastic plate, three nails, 50% propylene glycol (0.5 oz), and PVC flashing as walls in an X-shape following the recommendations of Koivula et al. (2003) (Fig. 4). The traps were alternated in which each transect was sampled twice for a week throughout the 6 weeks of the study. To sample arthropods in the trees and shrubs we used branch clippers and a white bed sheet. Three branches were clipped from three different trees per pitfall location at three different heights

Figure 4. Pitfall trap design with X-shaped guidance barriers used on the San Antonio Viejo Ranch, Jim Hogg and Starr counties, TX, USA in July-August 2019.

(lower canopy, center canopy, upper canopy), we visually analyzed the clipping for arthropods then beat branches onto the sheet to account for any remaining arthropods. We then placed a sheet directly under a shrub within 5 m of each pitfall trap and used a PVC pole to hit the shrub for 20-30 seconds to knock all arthropods onto the sheet. The sheet was dusted off each time and between each method to prevent double counting. Arthropods were counted and classified based on their order after each method.

Statistical Analysis

Data were analyzed using a multivariate multiple regression in RStudio using the stats package (RStudio Team 2020) to assess the influence of brush level and arthropod metrics on avian insectivore metrics. Predictor variables included brush cover levels and arthropod metrics. Response variables included avian insectivore metrics. Metrics for birds and arthropods were relative abundance, diversity, and richness. Relative abundances of birds and arthropods were calculated using the ratio of the total number of individuals counted by the length of the transect by week and transect. The Shannon-Weiner Diversity Index ($H = -\Sigma\ P_i(\ln P_i)$;$H$ = diversity, P_i = number of individuals of species i/ total number of samples) was calculated to measure the species diversity in each transect for birds and arthropods (Ali et al. 2016). The Menhinick's Index ($D = s\ \sqrt{N}$; D = species richness, s = number of different species represented in your sample, N = total number of individual organisms in your sample) was used to measure species richness in the area for both. Data for bird and arthropod metrics were log transformed to meet assumptions and are interpreted on the log scale.

RESULTS

We documented 407 avian insectivores and sampled 2587 arthropods. Bewick's Wren was the most abundant species in both the high and the low brush areas (Fig. 5). The Yellow-billed Cuckoo was the least abundant with none found in the low brush area and only one in the high brush. The Ladder-backed Woodpecker was not included in data analysis as there were birds in the area but they were not within the transect perimeter. There were more arthropod orders found in the high brush than the low brush with Hymenoptera being the most abundant order in both high and low brush areas (Fig. 6). Odonata, Siphonaptera, Trombidiformes, and Myriapoda were the least common orders found. Siphonaptera and Trombidiformes were found only in the high brush.

Avian diversity and avian richness were not significantly influenced by brush cover level or arthropod metrics (Table 1) but brush cover level and arthropod diversity had a significant influence on avian abundance ($P < 0.003$). Figure 7 demonstrates the interaction between arthropod diversity and brush cover. The effect of high brush

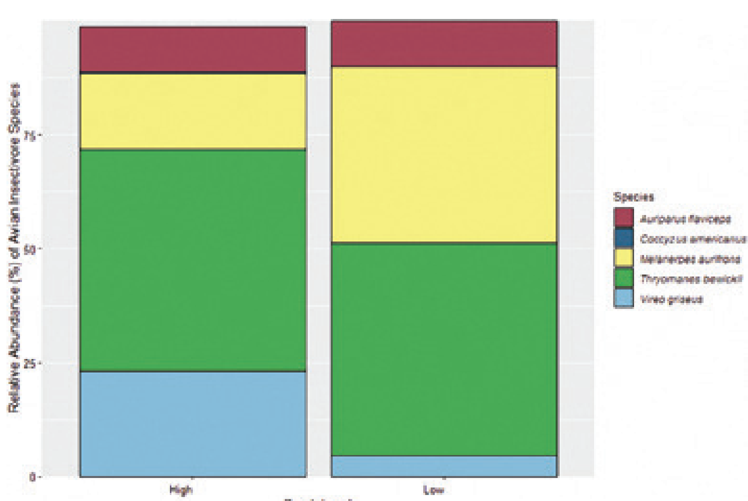

Figure 5. Relative abundance of avian insectivores in high and low brush areas on the San Antonio Viejo Ranch, Jim Hogg and Starr counties, TX, USA in July-August 2019.

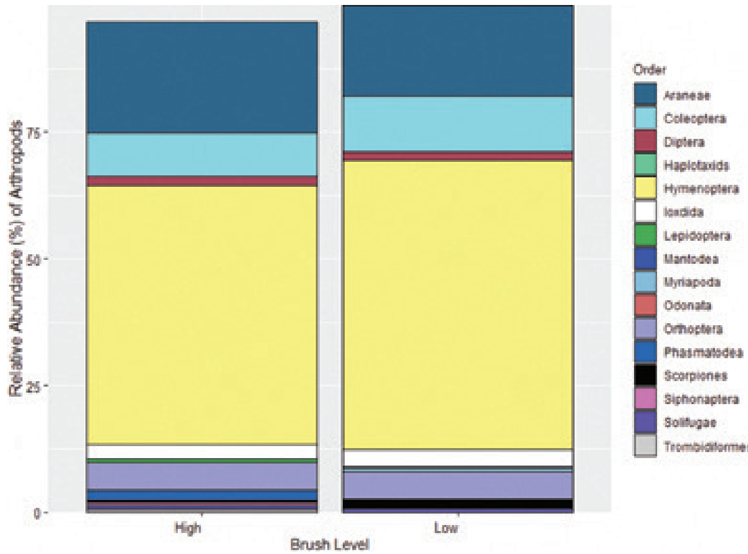

Figure 6. Relative abundance of arthropods in high and low brush areas on the San Antonio Viejo Ranch, Jim Hogg and Starr counties, TX, USA in July-August 2019.

cover on avian insectivores becomes more positive as arthropod diversity increases. The effect of low brush cover on avian insectivores become more negative as arthropod diversity increases. While there was a significant relationship between arthropod abundance and avian insectivore abundance ($P < 0.003$, Table 1) this was not as ecologically meaningful since the most abundant arthropod order (Hymenoptera) was primarily ants.

Table 1. Multivariate multiple regression results with log-transformed data for the effect of brush level cover and arthropod metrics on avian insectivore metrics on the San Antonio Viejo Ranch, Jim Hogg and Starr counties, TX, USA in July-August 2019.

Predictor	Response											
	Avian Relative Abundance				Avian Richness				Avian Diversity			
	Estimate	SE	t	P	Estimate	SE	t	P	Estimate	SE	t	P
Brush Level (Low, High)	0.080	0.120	0.664	0.515	−0.148	0.165	−1.651	0.197	0.082	0.151	0.547	0.712
Arthropod Relative Abundance	0.479	0.142	3.368	0.003**	−0.261	0.131	−2.00	0.061	0.042	0.119	0.354	0.728
Arthropod Richness	0.410	0.473	0.868	0.397	−0.350	0.434	−0.808	0.430	0.209	0.397	0.527	0.605
Arthropod Diversity	1.11	0.450	2.476	0.023*	−0.145	0.413	−0.351	0.730	0.108	0.378	0.286	0.778
Brush Level x Arthropod Richness	0.992	0.489	2.027	0.058	−0.256	0.449	−0.570	0.576	0.193	0.411	0.471	0.643
Brush Level x Arthropod Diversity	-2.81	0.831	-3.392	0.003**	1.02	0.762	1.34	0.199	-0.526	0.696	-0.775	0.466
Adjusted R^2	0.6438				-0.06169				0.1428			
F-Statistic	8.23				0.7676				1.666			

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.00$

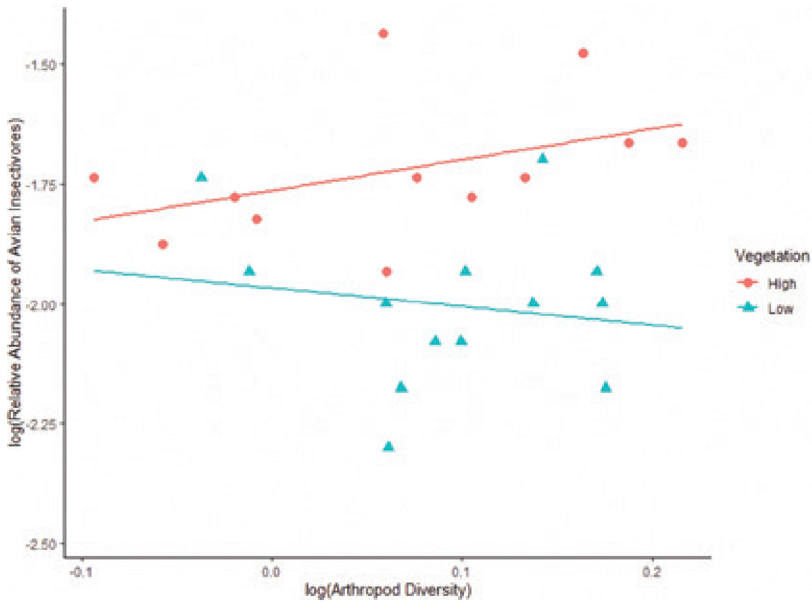

Figure 7. The effect of brush cover level (high and low) and arthropod diversity on the relative abundance of avian insectivores on the San Antonio Viejo Ranch, Jim Hogg and Starr counties, TX, USA in July-August 2019.

DISCUSSION

There was a higher total number of insectivorous birds found in the high brush than in the low brush, which was expected as birds look for places that provide the best coverage and have space to reproduce (Krausman 1999). There were 16 orders of arthropods identified, with the most abundant being Hymenoptera. Arthropod diversity and brush cover as an interaction had an effect on the relative abundance of birds which could be a result of birds having a broader diet. Since there was a higher diversity of arthropods in high brush, birds may not have to compete for one type of arthropod which may lead to a higher abundance of avian insectivores. Brush cover and arthropod metrics did not influence avian diversity or avian richness. This could have occurred due to that area already being high in avian diversity and richness therefore brush cover and arthropod metrics did not matter.

The relative abundance of arthropods was relatively equal which was expected since arthropods can live anywhere in the world and occur in almost any possible environment (Rosenberg et al. 1986). Fewer orders were found in the low brush than the high brush area which can be because the high vegetation provides more area for shelter and food (Rosenberg et al. 1986). Since there are fewer arthropod orders in the low brush, this should lead to less diversity in bird species as there is potentially more competition between avian insectivore species if they are specialists that seek out specific arthropod types.

Many environmental variables can affect the presence of birds. The Yellow-billed Cuckoo was found only in the high brush area which was expected since they are upper canopy gleaners meaning they spend an abundant amount of the time in trees (Graaf et al. 1985). More Verdins were found in the high brush area which is expected since they are lower canopy and shrub gleaners, and the high brush area is dense with vegetation. A higher number of Golden-fronted Woodpeckers were found in the low brush area, yet they are typically found in dense vegetation areas (Schroeder et al. 2013). Within the United States, Golden-fronted Woodpeckers are closely associated with mesquite brushlands and riparian corridors (Husak and Maxwell 2000), however in this study they were primarily found within grassland areas which may be due to food availability and vegetation condition. The number of Bewick's Wrens was relatively similar in both high and low brush which is likely due to the fact that they are a generalist species and can be found almost anywhere (Kroodsma 1985).

For both high and low brush, there were instances where no birds were recorded, which could have resulted for two reasons. There could have been possible human disturbance by the vehicle, and while it was parked at least 50 m from the start of the transect it could have possibly flushed any birds in the area. At times, birds were heard but they were not within the transect limits and therefore not recorded. Overall, there were also environmental factors that could have hindered the study. The temperature changed throughout the course of the five-week period. Temperatures rose from the start to the end of the study from 32° C to 38° C. At the beginning of the study, there were many more birds recorded as the temperature was at an ideal range for them to be active. As temperatures rose, less birds were recorded as birds are generally not very active in hot temperatures and it alters their activity (Vafidis et al. 2019). There are some birds, like the Yellow-billed Cuckoo, that were not vocal which could have reduced our opportunity of recording them during surveys. The Yellow-billed Cuckoo was seen or heard the least out of all the bird species of the study which can be a result of the species being active on the nest rather than vocalizing or foraging.

Further research is required to determine associations between arthropod and avian insectivore abundance. Having a longer study period or more transects would improve this study as it will give a better representation of the birds and arthropods in the area. Having additional observers in the study would also help as this would allow for multiple transects to be surveyed at the same time while covering more ground but will have to come with more rigorous analysis of observer reliability. Implementing these changes will yield improved information which will give a better representation of what is happening with our avian populations on South Texas ranches. Having information regarding the importance of brush cover will help ranchers make important land management decisions that help the wildlife that resides there.

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