Interdisciplinary Study on the Effects of Anthropogenic Structures on Urban Black-and-Gold Howler Monkeys (*Alouatta Caraya*) Troops of Pilar, Paraguay Through Both Local Ecological Knowledge and Naturalistic Observation.

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ABSTRACT. Black-and-gold howler monkeys (*Alouatta caraya*) in South America often use anthropogenic structures, such as electric cables, to travel across urban environments, which increases rates of mortality. The urban black-and-gold howler monkey troops in Pilar, Paraguay, offer a unique opportunity to understand the dynamic between humans, wildlife, and complex urban habitats. To provide baseline information, on the relationship between urban howler monkeys and human populations in Paraguay, I conducted an interdisciplinary study of monkey habitat use and citizen perceptions. From May to August 2021, I studied the two most-at-risk of electrocution monkey troops in Pilar to evaluate whether proximity to electric cables influenced monkey behavior. I grouped proximity to electric cables into 3 groups, < 5 feet, 5-15 feet, and > 15 feet, and I grouped behavior into 7 classes: resting, feeding, traveling, playing, mating, grooming, and other. I used a chi-square test to determine if there were any significant differences between monkey behavior and proximity. I then continued with a Bayesian multinomial model approach to examine whether proximity to cables affected behavior. I found evidence that monkey behavior differed across three levels of proximity to electric cables ($\chi 2 = 225.8$, $df = 12$, $P < 0.001$). Traveling was the most frequent behavior when within 5 feet of an electric cable, whereas resting was the most frequent behavior when greater than 5 ft from an electric cable. Based on the best fit multinomial model, monkey behavior was most strongly associated with the time of day and proximity to the electrical cables. Additionally, I explored the human perceptions of the monkey-cable issue by interviewing 104 community members. Within the community, the view of the monkeys ranged from being concerned about the general monkey-electric-cable issue to viewing the urban monkey populations as pests. The results of this study provide valuable sociological and ecological tools to further assess the nuances and future complexities of social-ecological issues in Paraguay.

Key Words: anthropogenic landscapes; human-nonhuman primate relationships, primates in urban settings, human dimensions, community-conservation involvement

Introduction

Over 60% of wild primates are threatened with extinction (Estrada et al., 2017). Urbanization is one of the greatest issues primates face (Estrada et al, 2017). The increase of urbanization comes with the increasing numbers of anthropogenic structures including electric cables and transformers, which many primates use to facilitate their travel across these urban landscapes (Dittus 2020, Katsis 2018, Pereira 2020). Howler monkeys are known to take advantage of electric cables for travel (genus: *Alouatta*; Lokschin 2007, Wellian and Smith 2021). The adaptability of the howler monkey to urbanization allows them to be frequent inhabitants of human environments (Clarke 1994; Clarke 2002; Crockett 1998; Mandujano 2006). However, the use of these structures increases the risk of death by electrocution (Lokschin 2007). This behavior, while catastrophic to the howler monkey populations, also destroys and damages cable connectivity throughout city landscapes and ultimately becomes a nuisance to surrounding human communities (Khatry 2006).

Black-and-gold howler monkeys (*Alouatta caraya)* have a geographic range stretching into Bolivia, Brazil, Uruguay (uncertain), Argentina, and Paraguay (Bicca-Marques et al. 2020). In this geographic range, there are increased rates of urbanization which have influenced howler monkey populations to inhabit ecologically fragmented urban areas (Baumann 2017, Kane 2020). On January 26th of 2015, the International Union for Conservation of Nature

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(IUCN) labeled black-and-gold howler monkeys as Near Threatened under the IUCN Red List of Threatened Species due to habitat loss, subsistence hunting, and population extirpations caused by disease (Bicca-Marques et. al 2020). With limited research on Paraguayan black-and-gold howler monkey populations, many populations affected by habitat loss and urbanization may be unaccounted for in the estimation and projection of the current categorization of black-and-gold howler monkeys on the IUCN Red List of Threatened Species. Identifying the potential and rising conflicts for black-and-gold howler monkeys increasingly cohabitating in urban landscapes is crucial for the conservation of the species. While there has been substantial research on wild black-and-gold howler monkey populations within Argentina and Brazil (Bravo 2003, Lokschin 2007; Printes et. al 2010), very little research has been conducted on both wild and urban populations in Paraguay. More specifically there have been very limited studies that integrate social and ecology studies examining the monkey use of electric transmission lines.

Within the field of conservation biology, researchers have spent more time on the traditional scientific and technical areas of research regarding species and ecosystems (Jacobson 1990). For successful human and non-human primate coexistence, it is critical for primate conservation in these dynamic urban areas to work with a variety of interconnected disciplines. Incorporating human dimensions in ecological research rooted in community-based collaboration may allow for sustainable progress in overall conservation (Jerusalinsky 2010, Bicca-Marques 2003, Kane 2020, Lindshield 2016).

Background

In Pilar, Paraguay, 15 howler monkey troops of roughly 3 -11 troop members are known to travel by electric transmission lines (Wellian and Smith 2021). At least 2 of the 15 troops of howler monkeys, the Cotton Factory troop, and the Crucecita troop are especially at risk of electrocution. In the months of September and October of 2017, three individuals of the Cotton Factory troop died by the same transformer which resulted in a 30% decrease in the size of the troop (R Smith, Para La Tierra, personal communication, January 2021).

This project aims to examine how the behavior of howler monkeys varies with proximity to electric cables as well as evaluate local perceptions of the issue and possible overlapping conflicts with the cable networks. My specific objectives were to: 1) evaluate the influence proximity of electric cables has on overall howler monkey behavior; and 2) analyze responses of surveyed residents of Pilar to evaluate how local perceptions on the issue align with the estimated risk of electrocution for the monkey troops. I will use the combined results of my social-ecological study to provide baseline data to develop future and more extensive studies on human-wildlife conflict in Pilar, Paraguay in partnership with the non-profit conservation organization Para La Tierra (PLT), the Ministerio del Ambiente y Desarrollo Sostenible (the Paraguayan Ministry of Environment and Sustainable Development), the Municipalidad de Pilar (Municipality of Pilar), and the local electric company ANDE. To promote informed decisions and support the priority in elevating positive human-wildlife coexistence, the results will be shared with Para La Tierra to be disseminated with Paraguayan decisions makers.

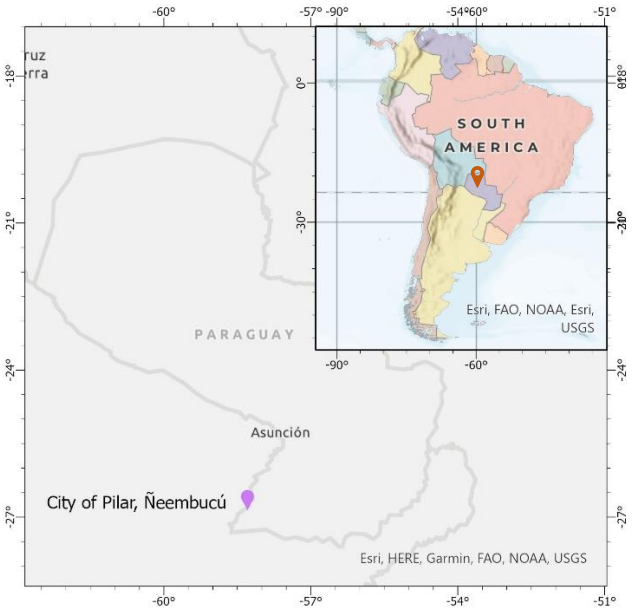

Figure. 1 Location of Paraguay within South America (orange pin; top-right). Location of Pilar within Paraguay (purple pin; bottom-left).

Methods

Ethics Statement

My research was approved by the Ministerio de Ambiente y Desarollo Sostenible (MADES) and the scientific committee of the Fundación Para La Tierra. I received a Montana State University Institutional Review Board protocol exemption for surveys that involves human subjects as well as a Montana State University Institutional Animal Care and Use Committee protocol waiver from the Office of Research Compliance at

Montana State University. I conducted interviews in accordance with the local laws of Pilar, Paraguay. Prior to each interview, interviewees were provided background information on the researchers and the overall project. After understanding the implications of the research, informed verbal consent was obtained to respect Paraguayan laws and cultural standards as a physical consent form or monetary compensation would be considered abnormal in the local context. Verbal consent was also received by the participants in the agreement of audio recordings. Participants were given the choice of one of Paraguay's two official languages - Spanish or Paraguayan Guaraní (indigenous language) and interviews were led by the local translator.

Study Site

Data were collected between May-August 202 in Pilar (26°51'31.5" S, 58°18.383' W), the capital of the Ñeembucú department of Paraguay. Pilar has a population of roughly 33,000 people (Ñeembucú Proyección de la Población por Sexo y Edad 2015). Pilar is located within the largest wetland within Paraguay, the Ñeembucú Wetlands Complex, a swamp-like habitat with humid Chaco gallery forests and grasslands (Alesci 2022). Between May to August, Pilar experiences an average temperature of 20 ℃ – 24 ℃ and 98.1 mm in average rainfall (www.worldweatheronline.com). There are approximately 69 individual monkeys occurring in 15 troops within the town with an estimated density of 2.18 howler monkeys per hectare of suitable habitat which often overlaps residential gardens and open green spaces (Wellian and Smith 2021; Para La Tierra, unpublished data). Two troops of the 15 within Pilar were studied: Crucecita troop, four individuals, and Cotton Factory troop, six individuals (Figure.2).

Ecological Data Collection

I began behavioral state sampling (Altmann 1974) at sunrise (6:30 – 7:00) and ended at sunset (17:00 – 17:30) four days a week. The timing of sunrise and sunset varied across the months due to seasonal changes. I used previously created home range estimation maps in Para La Tierra's research database were used each day to identify areas to locate the troops. Between the Crucecita troop and the Cotton Factory troop, only one troop was observed a day. If a troop was not found within 1-2 hours, the other troop would be observed, with the goal of both troops being observed over the season for equal amounts of time. I observed each troop using scan sampling, a large group instantaneous sampling method (Altmann 1974). The behavior of each individual of the troop was observed and recorded for one minute. After one minute, a 5-minute time period served as a "rest period" where no observations were recorded until the next one-minute scan sample. I repeated this process for the entire survey period. Behavior states included playing, feeding, resting, grooming, traveling, mating, and other. Along with data on behavior states, individual's distance from the cable (less than 5 ft., 5-15 ft., greater than 15 ft.), whether the cable was in use, age and sex, and GPS coordinates of each scan were also recorded.

Ecological Data Analysis

Contingency tables and mosaic plots were established as a preliminary descriptive route of data analysis through initial general statistics on the total observations of howler monkey behavior and its relationships with the proximity groups to the electric cables. For the contingency tables, rows represented the predictor variable, levels of proximity (< 5 feet, 5-15 feet, > 15 feet) to electric cable and columns represented the response variable, different categories of behavior (Gotelli 2018). I used mosaic plots to visually compare and summarize the data. Behaviors, distance classes, and time-of-day classes were contained into abbreviated categories for the data analysis (Table.3).

Table.3 In the data analysis, abbreviations were used to categorize monkey behaviors, distance classes, and time classes. These abbreviations were also used in the graphical representations of the results (Figure.4 - Figure.9).

Behaviors	Description
traveling	-
testing	-
group	Refers to group behaviors such as grooming, mating, and playing
Distance Classes	
close	less than 5 feet
mid	5 – 15 feet
far	greater than 15 feet
Time Classes	
earlyam	7:00 am – 8:59 am
lateam	9:00 am – 10:59 am
noon	11:00 am – 12:59 pm
earlypm	1:00 pm – 2:59 pm
latepm	3:00 pm – 5:00 pm

A chi-square test was used to initially interpret the significance of the relationship between behavior and proximity. I used a multinomial model to further assess

the relationships between proximity to electric cables (Koster & McElreath 2017). Using the brms package in R, a Bayesian multinomial model was fitted using Stan, a probabilistic programming language (Bürkner 2017). Monkeys that were not uniquely identified were removed from consideration. The multinomial mixed model included correlated random effects for each of the identified individuals to account for potential behavioral autocorrelation (Koster and McElreath, 2017). I began with a model that included distance (within 5 feet, 5-15 feet, and more than 15 feet), a variable that describes both the age and sex of the monkeys (juvenile, subadult female, subadult male, adult female, adult male), time period (7:00-8:59, 9:00-10:59, 11:00-12:59, 13:00-14:49, and 15:00-17:00), and group (Cotton and Crucecita) as categorical covariates. I then fitted an additive model that included each of the categorical covariates as additive predictors. I assessed the model fit of all developed models using the Widely Applicable Information Criterion (WAIC). For all models, effects plots were created to display the estimated probabilities of each behavior based on the various levels of the categorical explanatory variables. The random subject effect was held at 0 (Figure.12-15).

Sociological Data Collection

I conducted interviews with 104 citizens of Pilar. To identify possible participants, I used convenience sampling (Longhurst, 2003; Crouch, 2006). Interview questions were initially constructed in English. Paraguayan citizens and local translators the written questions into Spanish or Guaraní during the interview. Ayala Santacruz facilitated each survey. Notes were compared to reach a consensus about the responses of each participant. Participants were assigned an anonymous ID and information on age group, sex, and GPS coordinate of the location of the interview.

The interviews were dynamic and depended on the answers of the interviewee. I established 10-13 questions to facilitate a semi-structured interview (Longhurst 2003). All questions were phrased in an open-ended manner to provide in-depth socio-contextual and descriptive responses that will enrich the qualitative data analysis (Vaismoradi 2016). I conducted interviews twice a week once on a weekday and once on a weekend day. Interviews were conducted outside of the homes of the participants, so interviews were highly dependent on the weather given that participation also depended on proper weather. The survey sample was divided into four interview groups: A) residents near the Cotton Factory troop, B) residents near the Crucecita troop, C) the general public, and D) employees of the Administración Nacional de Electricidad or ANDE. Non-random sampling was used for the Cotton Group (A) and Crucecita (B) interview survey groups to identify homes that might have more frequent interactions with the troops given their close proximity to the troop range. As for the General Public (C) interview survey group, non-random sampling was used as participants were widely based on convenience. Three employees of ANDE, the national electric company of Paraguay, were also interviewed to supplement the current responses under the perspective of the agency which manages the electric cables. The semi-structured interviews lasted between 5-30 minutes.

Each interview covered three-question domains where the following domains after the first remained dependent on the responses of the interviewee. The total three domains included general information, expressed concern, and indifference or lack of concern (Table.2; Figure.3).

Sociological Data Analysis

A thematic content analysis was performed in NVivo (released in March 2020), a software program designed to analyze qualitative and mixed media research. To begin a thematic analysis, the responses to all open-ended questions were reviewed and the common themes and words were noted across each review. The patterns of meaning, also known as themes, across the responses were centered around the topic and research question of this study (Braun & Clarke 2012). I followed the six-phase approach to thematic analysis as described in Braun & Clark, 2006. In the first phase, I familiarized myself with the data by reading and rereading the textual data and listening to the consented audio recordings. In the second phase, I generated the initial codes that interpret the data content and specify aspects of interest within the dataset as it relates to the research question. In the third phase, I transformed the codes into broader themes that reflect the pattern of responses and meanings in the data. Once all relevant themes to the patterns were generated, I reviewed the potential themes in phase 4 to refine the themes to be representative of the coded data and the entire dataset. In phase 5, I defined and named the themes to offer a unique label for each thematic parameter. Seven thematic parameters were established to explore the nuances of community perspectives across the monkey-cable issue (Table.1). Finally, in phase 6, I produced a report of the analysis as in this article.

Results

I collected 5267 observations of monkeys from May to August 2021 (Figure.4). Around 73% of observations were monkeys greater than 15 feet from an electric cable, 22% were between 5 to 15 feet, and 5% were less than 5 feet from an electric cable. Monkeys less than 5 feet to an electric cable primarily traveled (54% of observations; Figure.5) As for monkeys greater than 5 feet from electric cables, resting was the most common behavior (59% of monkeys 5 and 15 feet; 60% of monkeys greater than 15 feet; Figure.5). As for group activities (playing, mating, grooming), monkeys greater than 5 feet from electric cables participated in group activities more than monkeys within 5 feet of cables (5% for within 5 and 15 feet, 4% for greater than 15 feet, 1% for less than 5 feet). Resting was observed to be proportionally larger in proximities greater than 5 feet from electric cables (59% for 5 to 15 feet, 60% for greater than 15 feet) than within 5 feet of an electric cable (21%).

Among sex classes, 42% of observations were female monkeys and 58% were male monkeys. Monkey behavior was generally similar across sex classes. Within 5 feet of electric cables, there were slight potential differences in behavior. There was a larger proportion of females resting near the electrical cables (28%) as compared to males (13%). As for similarities, traveling was the most common behavior for both male (58%) and female monkeys (49%; Figure.6).

The Cotton Factory and Crucecita troops exhibited similar behaviors in relation to transmission line proximity (Figure.7). When within 5 feet from an electric cable, 69% of Crucecita observations were traveling in comparison to 50% of Cotton Factory observations. However, when within 5 feet of an electric cable, the proportion of feeding behavior in Cotton Factory (0.27) was much larger than the proportion of feeding occurring in the Crucecita group (0.13; Figure.7).

Observed monkeys were classified into one of three age classes: juvenile, subadult, or adult. Adult monkeys composed 77% of observations, subadults 14%, and juveniles 9%. Within 5 feet from an electric cable, regardless of age class, all monkeys predominately traveled in this proximity. There was a higher proportion for resting for subadults and adults while greater than 5 feet from electric cables (subadult: 51% for 5-15 feet, 54% for greater than 15 feet; adult; 63% for greater than 5 feet) Whereas juveniles spent a larger proportion of time traveling (juvenile: 21% for 5-15 feet, 43% for greater than 15 feet; Figure.8). 7:00-8:59, 9:00-10:59, 11:00-12:59, 13:00-14:49, and 15:00-17:00),

For the time-of-day classes, there were differences in monkey behavior across time categories. Early morning (7-9 AM), no monkey individuals were observed to be within 5 feet of electric cables. As the day progresses, the proportion of monkeys to be within 5 feet of an electric cable progressively increased concurrently with behavioral changes. For example, during 11 AM – 1 PM monkeys within 5 feet of the electrical cable are primarily traveling (79%), whereas during 9 AM – 11 AM monkeys within 5 feet of an electric cable are traveling less (33%; Figure.9).

Ecological

Objective 1: Analyze the influence proximity of electric cables has on overall howler monkey behavior.

In the preliminary analyses, I found evidence that the behavior of all troop members across both groups differed among the distance classes related to proximity to power lines ($\chi 2 = 225.78$, df = 12, and p-value < 2.2e-16). Across the seven behavior types feeding, other, resting, and traveling behavior were the most observed behaviors. The top four behaviors were condensed into a single contingency table to display and summarize the most pertinent data (Table.4).

Table.4 Contingency table of the top four most prevalent behavioral observations (feed, other, rest, travel) by the three proximities (< 5 ft, 5-15 ft, > 15 ft) was established to summarize the most pertinent behavioral data collected.

Proximity to Cables	Behavior			
	Feed	Other	Rest	Travel
< 5 ft	58	4	49	126
5-15 ft	185	38	675	240
> 15 ft	553	30	2266	843

Traveling behavior was more common when a monkey was within 5 ft of an electric cable (Figure 10). Traveling was the most frequently observed behavior when a monkey was less than five feet whereas proximities greater than 15 feet had resting as the most frequently observed behavior. While the ratios slightly change, traveling remains the most observed behavior for both groups with proximities less than 5 feet to a cable. The Cotton group has an equal amount of resting occurring in a proximity of 5 to 15 feet and greater than 15 feet. There are also many more observed feeding occurrences in the proximity of fewer than 5 feet. The Crucecita group has

more resting occurring in the proximity of greater than 15 feet and equal feeding behaviors across all three proximity groups (Figure.11).

In comparing the WAIC across all models, I found that the model with the best predictive ability contained time of day and proximity to the electrical cables. In the model which accounted for the repeated measurements of monkey individuals, time of day and proximity to the electrical cables appear to be associated with changes in monkey behavior.

Sociological

Sociodemographic Information

The survey sample consisted of 104 individuals where 1 (0.96%) participant was a child, 8 (7.69%) were young adults, 63 (60.58%) were adults, and 31 (29.81%) were senior citizens (Table.5). Apart from the three employees interviewed at ANDE, 33-35 residents were interviewed per survey group.

Table.5 The demographics (age and sex) of all 104 interviewees in the sociological survey sample conducted in Pilar, Paraguay (A = General Public, B = Crucecita, C = Cotton Factory, D = ANDE).

	A	***B***	***C***	***D***	***Total***
Age					
Child	0	0	1	0	1
Young Adult	4	2	2	0	8
Adult	26	18	17	2	63
Senior Citizen	3	15	13	1	32
Total					104
Sex					
Male	21	16	20	3	60
Female	12	19	13	0	44
Total					104

Objective 2: Analyze responses of surveyed residents of Pilar to evaluate how local perceptions on the issue aligns with the estimated risk of electrocution for the monkey troops.

There were seven parameters of the thematic content analysis: express concern for monkeys (n=41), express concern for humans (n=12), monkeys as pests (n=43), nature connectivity (n=22), expressed connection with monkeys (n=15), notions of neutrality (n=7), and separatist mentality (n=21) (Table.6). For the preliminary monkey identification question, 9.6% of participants were unsure of their decision, 44.2% of participants were incorrect, and 43.3% of participants were correct (Table.7).

Table.6 Number of occurrences for each most highly referred theme.

Parameter	Number of Occurrences
Concern for Monkeys	n = 41
Concern for Humans	n = 12
Pest-like Nature of Monkeys	n = 43
Connectivity with the Natural World	n = 22
Empathetic and Shared Connections with Monkeys	n = 15
Notions of Neutrality	n = 7
Human Exceptionalism & Separatism	n = 21

Table.7 Number of correct, incorrect, and uncertain responses of participants when asked to identify the correct monkey species present in Pilar, Paraguay.

Response	Number of Occurrences
Correct	n = 45
Incorrect	n = 46
Unsure	n = 10

Discussion

Ecological

The results of this study provide preliminary evidence that proximity to cables as well as the time of day is associated with changes in monkey behavior. Typically, howler monkeys spend the majority of their day resting, (> 66%; Van den Bosch 2013). Specifically, black-and-gold howler monkeys spend more time traveling and moving than other howler monkey species such as the brown howler (Agostini et al. 1974, Zunino et al. 2007). However, as a species with behavior patterns that have a larger fraction of time spent traveling, particularly in an urban setting, the likelihood of electric cable interactions may be greater for black-and-gold howler monkeys. As an extension of this study, a further analysis across multiple howler monkey species might illuminate additional causations for the likelihood of cable usage. As such,

black-and-gold howler populations in urban settings may have higher priority for mitigation of negative interactions with electric cables. Based on the evidence of this study and typical behavioral patterns, the Pilar black-and-gold monkey troops spend a greater proportion of time traveling when within 5 feet of a cable. While further analysis is needed, if states of rest are signifiers of perceived safety by the howler monkeys and proximity less than 5 feet to electric cables is predominately traveling behavior, then it can be inferred that there is an anticipated risk when near electric cables (Wellian and Smith 2021). This contradicts previous analyses which have suggested that Pilar monkey troops have a lack of risk awareness for electric cables. This suggestion is due to proposed hypotheses that the monkeys are incapable to distinguish safe (insulated) versus dangerous uninsulated) cables since individual learning is not possible due to limited survival during "dangerous" cable interactions (Wellian and Smith 2021). While my study does not provide a mortality risk assessment, the results provide evidence that there may be unaccounted effects of electric cables on howler monkey risk awareness given the associated changes in behavior. For more information, future studies may consider using a combination of behavioral factors or a hormonal analysis. If electric cables influence the Pilar howler monkey behavior, which may ultimately affect their overall survivorship in an urban landscape, the increase of stress may result in other complications of monkey wellbeing (Marsh et al. 2013). However, since the cables are primarily used by monkeys as a mode of travel in limited circumstances to travel across disconnected patches of the canopy, establishing higher connectivity between forest patches can mitigate the usage of electric cables (Lokschin 2007).

Time of day was also found to be a significant variable in the relationship between proximity to electric cables and monkey behavior. Since activity levels of black-and-gold howler monkeys vary across the day, incorporating time of day into future research approaches will be necessary to account for additional and potential impacts on the overall behavioral data. However, given there are no observations for monkeys from 7-9 am within 5 feet of the electrical cables, incorporating and estimating the time-of-day interaction term may cause computational difficulties.

As the data collected was obtained from two troops (4-6 troop members), there were unavoidable repeated measures due to small troop sizes. For many behavioral ecology studies, it is common to observe individuals on multiple occasions, however, this causes pseudoreplication which requires statistical models that will account for higher-level clustering (Bolker et al. 2009, Koster and McElreath 2017). With repeated measures, relationships between each of the variables and behavior may have confounded my inferences as each repeated measure lacks independence in the observation. As an extension to this study which aims to explore the impacts of electric cable proximity on the behavior response changes based on the age and sex variable, group, or time of day, a frequentist framework may be considered to alleviate the complexities of the computational time.

Sociological

I found that the people of Pilar had a wide range of perspectives regarding the presence urban monkey populations and perspectives on the electric-cable issue. My goal by performing a thematic content analysis was to give expression to the commonality of voices across interview participants, which allowed the theme groups to uniquely represent the survey data as a whole (Anderson 2007). Of the seven theme parameters "Concern for Monkeys", "Pest-like Nature of Monkeys", "Connectivity with the Natural World", and "Human Exceptionalism & Separatism" were the largest thematic groups. Concern for monkey wellbeing in an urban setting was near equal in occurrence with sentiments of pest-like annoyance for the urban monkey populations. Similarly, sentiments of connectivity of natural and urban landscapes and human-wildlife separatist responses were also near equal in occurrence. However, in 2017, Pilar residents were found to have overall positive attitudes toward the urban howler monkeys and emphasized that the monkeys provide benefits to the city and that they should be protected from the rising risks of the urban landscape (Alesci et al. 2022). Based on the results of this study, people's opinions of the Pilar urban howler monkeys have gotten less tolerant given a near equal occurrence of positive and negative perceptions rather than a high skew towards positive sentiments as seen in Marco et al. 2022. This shift in community attitudes could be due to the effects of COVID and the isolation of staying indoors, growing urbanization, or a limited interview sample size. The primary goal of incorporating a sociological approach was to include these perspectives as a framework for future studies and solutions. The presence of equal occurrences between opposing perspectives may cause difficulties in the incorporation of local knowledge into future studies. The complexities of the results further emphasize that extended surveys and analyses are needed to better understand what approaches the best suit both community members and the local black-and-gold howler monkey populations. The divided results of the data

provide a crucial starting point to understanding the duality of this issue and in what ways compromises can be made in addressing the complexities of human-wildlife interactions and landscapes in the Pilar.

This study not only illuminated the potential relationships of at-risk Pilar howler monkey troops with electric cables but also initiated the preliminary steps towards community conservation involvement. The duality of ecological and sociological analyses is beneficial for the beginning stages of community-based natural resource management (NRM), a method that builds upon the traditional management practices of the community (Springer et al. 2011). Research indicates there is higher conservation success in community-led projects, making it an effective and sustainable conservation approach (Brooks et al. 2012). While this study remains specific to the Pilar community within Paraguay, the pursuit to understand the dynamics between wildlife and human populations across shared landscapes is a shared effort across regions, landscapes, and nations.

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Table.1 Seven thematic parameters of the social survey.

Theme	Description
Theme 1: Concern for Monkeys	Focuses on the degree to which participants shared a spoken concern for the well-being of monkeys in electrocution situations and the difficulty dealing with the death of a monkey individual.
Theme 2: Concern for Humans	Focuses on the degree of which participants expressed a greater concern for human wellbeing in interactions with monkey troops or in the events of monkey-cable interactions. Some participants heavily weighed the costs that issues between monkeys and cables have on the electrical connectivity of the town and in other cases the aggression the monkeys have shown to citizens of Pilar.
Theme 3: Pest-like Nature of Monkeys	Outlines participants experiences with monkey troops during their daily lives in Pilar, Paraguay. Few examples shared which conveyed pest-like annoyance of participates included issues between monkeys and companion animals (ex. dogs), monkey feces issues on laundry and gardens, noise, and aggression.
Theme 4: Connectivity with the Natural World	Focuses on participants tendency to offer insight, perspectives, and solutions that followed an understanding of a dynamic growing landscape. The answers of participants had the tendency to share perspectives which reflected considerations that the Pilar area is a shared space between humans and wildlife. They also brought in many thoughts on the effects and outcomes of urbanization.
Theme 5: Empathetic and Shared Connections with Monkeys	Outlines the manner in which participants weighed the emotional distress that monkey deaths and monkey-cable interactions have on their own personal

	wellbeing. They frequently supplemented their opinions with comparisons of the physical and emotional similarities of monkeys to people.
Theme 6: Notions of Neutrality	Focuses on participants hesitations in forming opinions on the monkey-cable issue. They consistently lacked responses or opinions to a variety of questions regarding the relationships between monkeys and human populations in Pilar.
Theme 7: Human Exceptionalism & Separatism	Outlines the ways in which participants expressed the issue as purely a monkey issue or purely a human issue such as with the electric companies. This thematic group is different from the "Concern for Humans" group in that these instances reflected an explicit separation between who gets affected and what outcomes of this issue should be prioritized in fixing.

Table.2 Three domains of the semi-structured interview format.

Interview Domains	Description
General Information (1 closed, 6 open)	The interview opened in an identification question in which participants were requested to identify which primate species they believe to be in Pilar. The selection included a combination of native and non-native species to Paraguay: a black-and-gold howler monkey, olive baboon, black tailed-silvery marmoset, and a hooded capuchin. Following the initial identification task, participants were asked broad questions regarding the traveling habits of black-and-gold howler monkeys then the questions slowly led to focus on the monkey's connection with the electric cables within Pilar. This first domain ended in asking participants to describe their thoughts on the dangers of the cables for the monkeys to determine the domain of questions the participant would be asked in the following phase of the interview.
Expressed Concern (6 open questions	Participants were asked to describe personal accounts of electrocutions and how either the witness or repercussions of this electrocution affected their daily life such as power outages or emotional response. Participants were asked to estimate the frequency of electrocutions and locations of each account. Participants were then asked if they believe solutions need to be made and if so to describe possible solutions they would like to see the city of Pilar facilitate to resolve this issue. Lastly, the interview was ended by asking if there are any other problems between urban life and the howler monkey populations, broadly.
Indifference or Lack of Concern (3 open-ended questions)	Participants were asked to recall any knowledge of howler monkey deaths during their time in Pilar. Regardless of the answer to the first question, participants were asked to describe a situation in which electrocutions of large macrofauna such as howler monkeys might be a potential problem in an urban setting. Like the last domain, participants were asked to provide any other insight on other problems related to the coexistence between humans and howler monkeys.

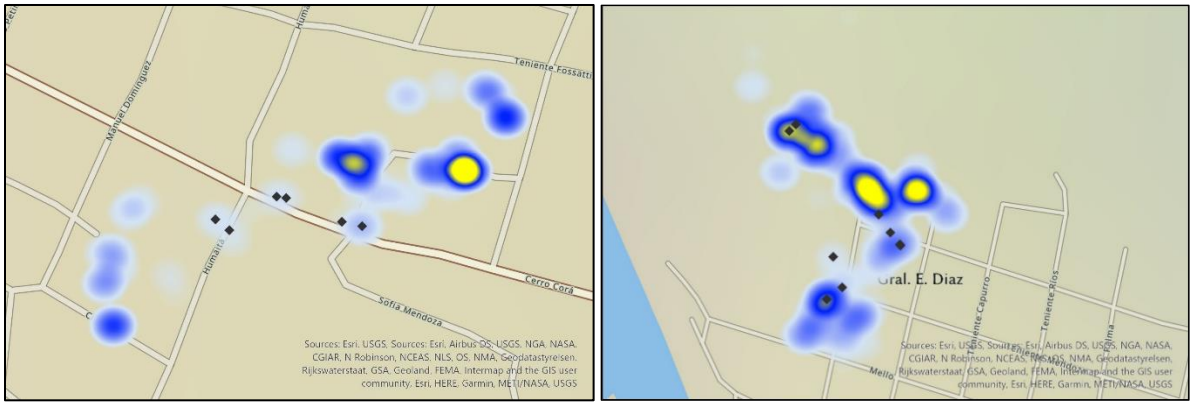

Figure.2 Heat maps for frequency of observations for the Cotton Factory troop (left, n=3058) and Crucecita troop (right, n=2181). Black diamonds represent locations of cable usage.

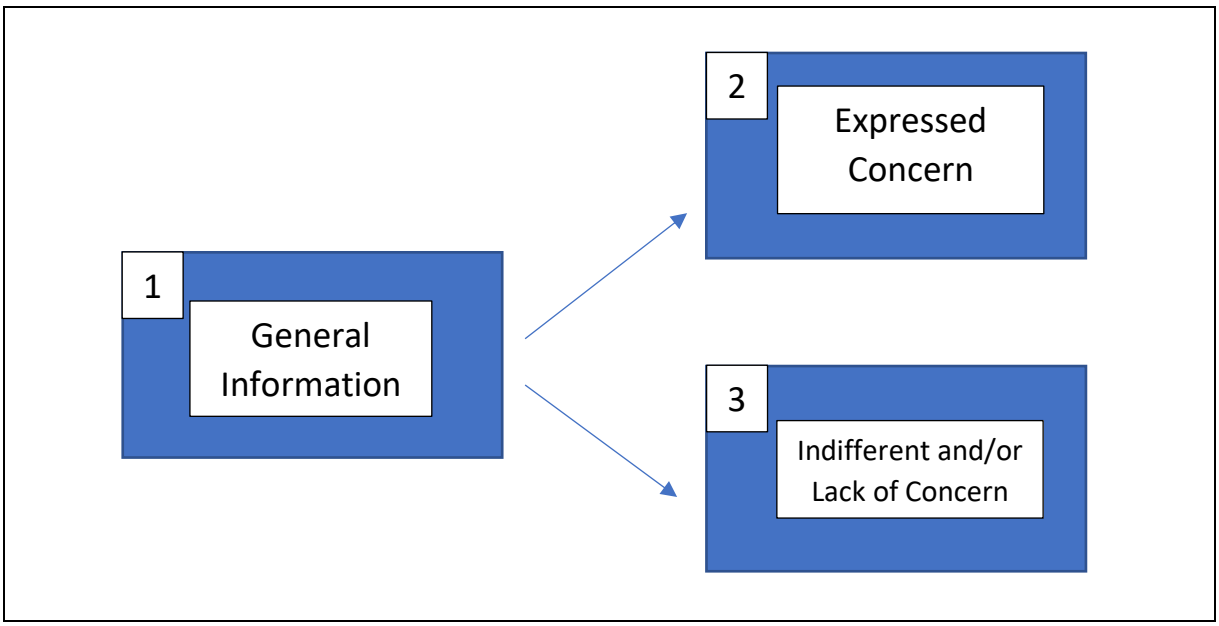

Figure.3 Visual of the dynamic semi-structured interview format. After 1) general information questions, interviews diverged to a particular set of questions if participants had 2) expressed concern or 3) remained indifferent and/or lacked concern.

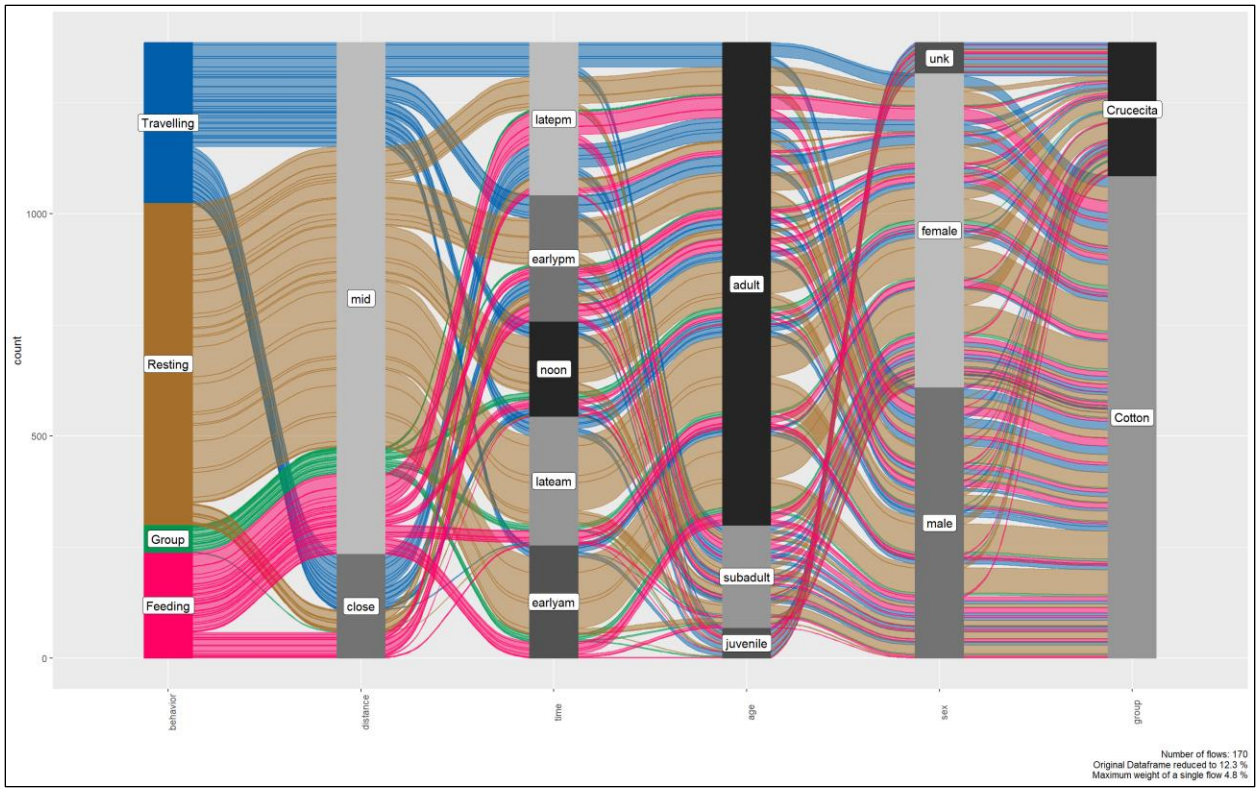

Figure.4 Alluvial diagram displaying the patterns of observations, colored by their behavioral response.

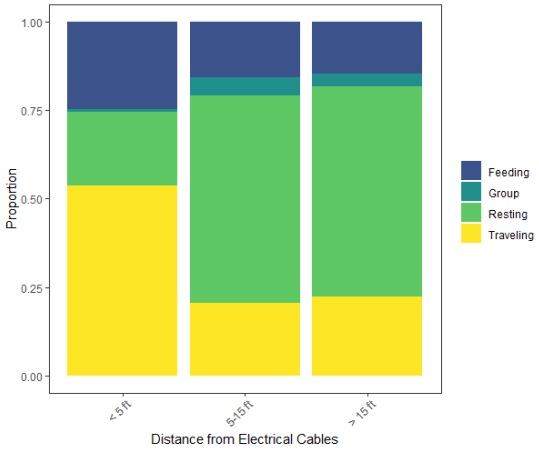

Figure.5 Stacked bar chart of monkey behavior by proximity to electrical cables.

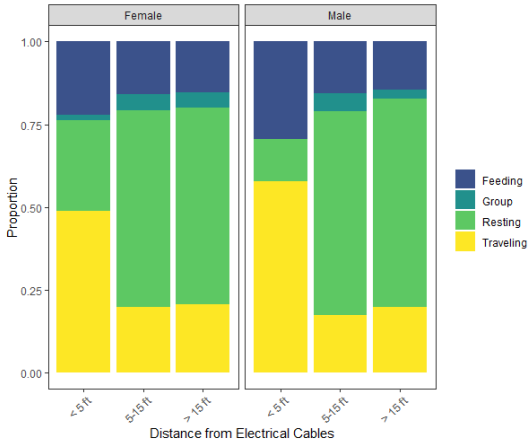

Figure.6 Stacked bar chart of monkey behavior by proximity to electrical cables, faceted by sex

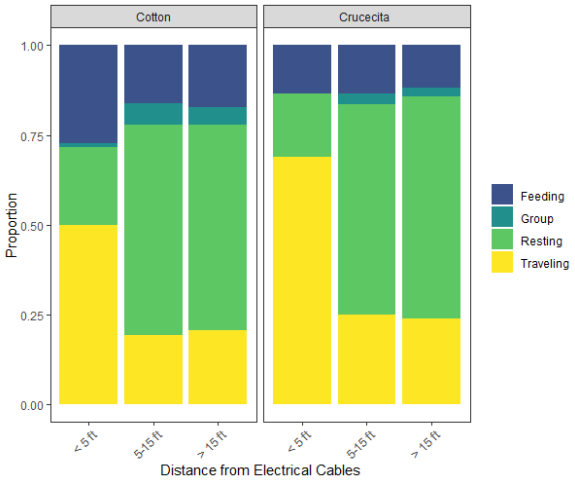

Figure.7 Stacked bar chart of monkey behavior by proximity to electrical cables, faceted by group.

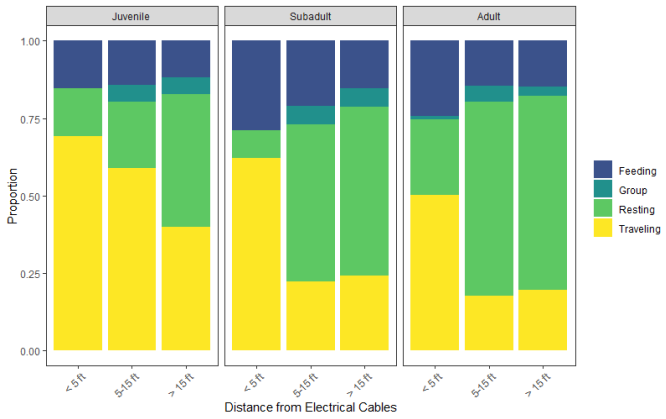

Figure.8 Stacked bar chart of monkey behavior by proximity to electrical cables, faceted by age.

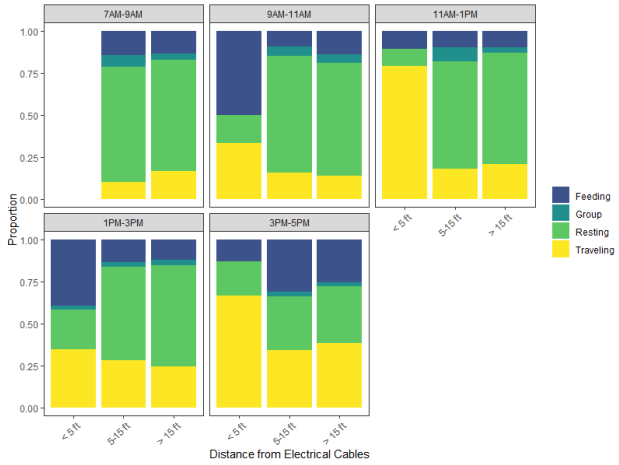

Figure.9 Stacked bar chart of monkey behavior by proximity to electrical cables, faceted by time of day

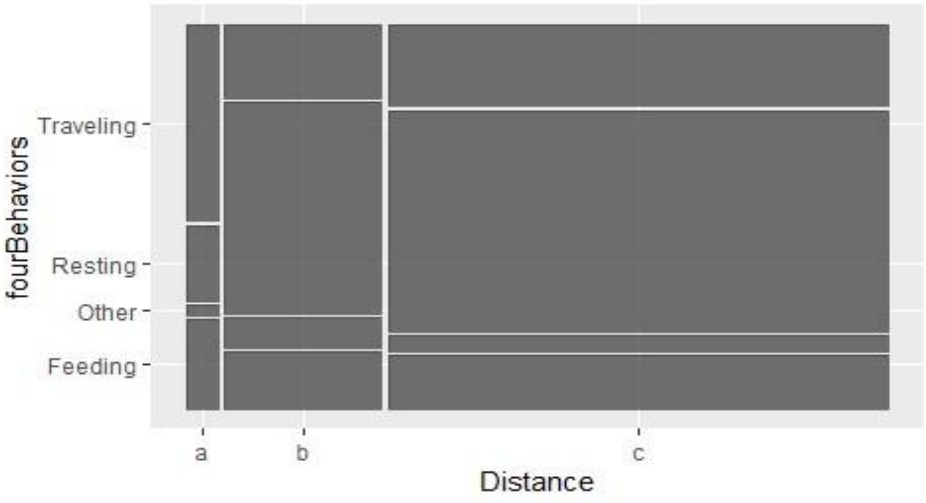

Figure.10 Mosaic plot of the top four behavior types across three proximities over both the cotton and Crucecita study groups; a = less than 5 feet, b = 5 – 15 feet, c = greater than 15 feet.

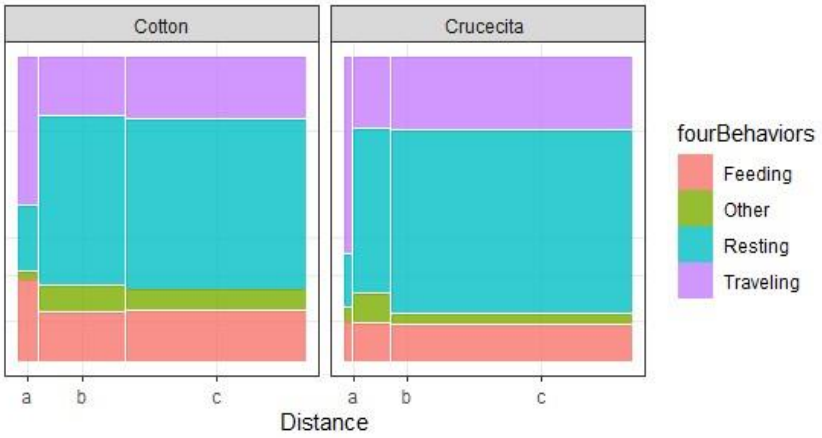

Figure.11 A condensed mosaic plot of the top four behavior types over three proximity groups divided by the two study groups: Cotton and Crucecita.

Effects Plots for Reference:

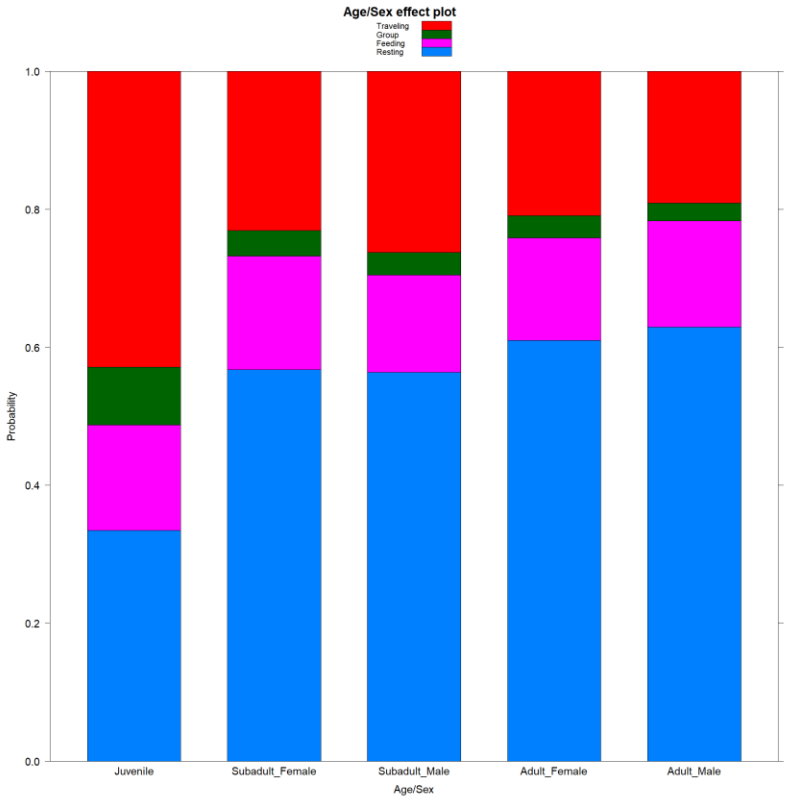

Figure.12 Age and sex effect plot.

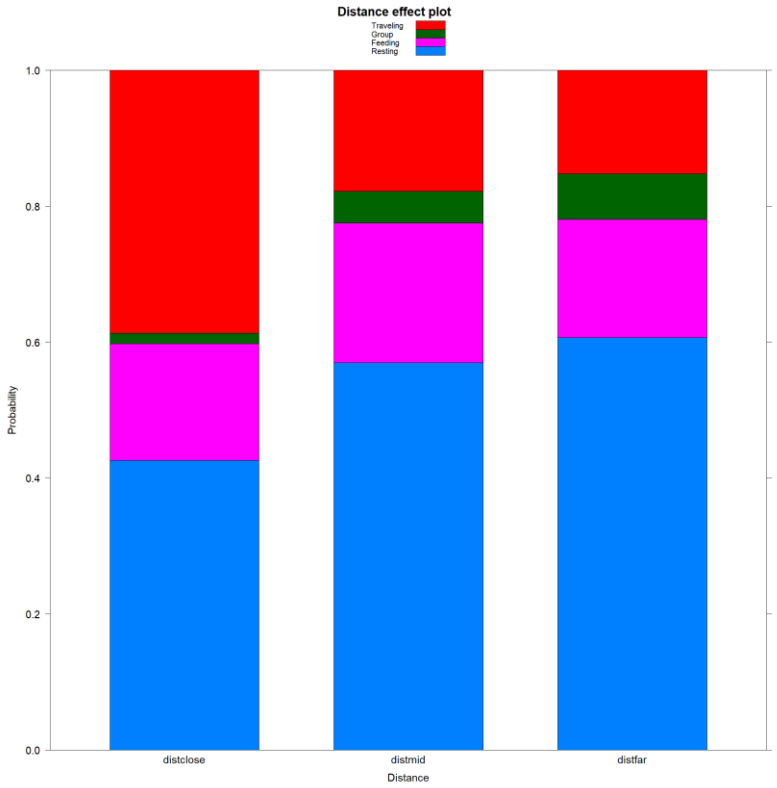

Figure.13 Distance effect plot (distclose = < 5 ft, distmid = 5-15 ft, distfar = >15 feet).

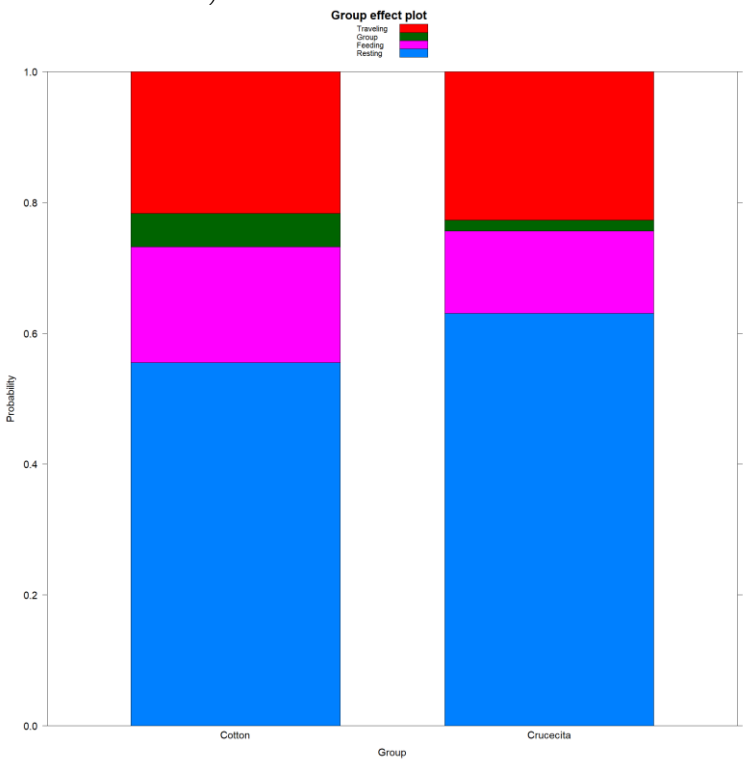

Figure.14 Group effect plot (left = Cotton Factory, right = Crucecita).

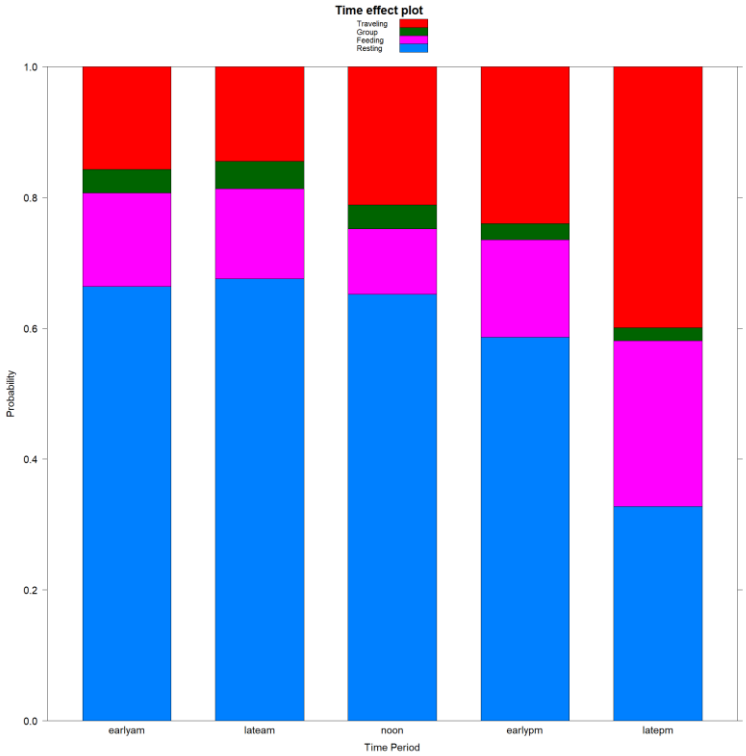

Figure.15 Time effect plot (earlyam: 7:00 am – 8:59 am, lateam: 9:00 am – 10:59 am, noon: 11:00 am – 12:59 pm, earlypm: 1:00 pm – 2:59 pm, and latepm: 3:00 pm – 5:00 pm).