Comparison of Bird Specie Abundance at Waking and Roosting Periods in Regenerating Agroforest

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Abstract

Agroforestry is one of the most important tropical agricultural systems, covering over 6.4 mil km^2 (13%) of agricultural land. These ecosystems can be designed to optimize both biodiversity and crop production benefits without adding pressure to convert natural habitat to farm land due to the vegetation structure which can both mimic natural forest habitat and promote natural regrowth. The purpose of the study is to document what bird species are using the agroforestry ecosystem at Finca Las Piedras as it develops and to determine whether it is more beneficial to monitor in the morning, during the dawn chorus, or the evening, when the birds return to roost. Birds can be excellent indicators of wider environmental health particularly when assessments use summarized data from a wide range of species as some species can be more sensitive to changes in abiotic factors or habitat, while some species can be generalists.

Introduction

As the human population increases, the demand for agricultural expansion and intensification is becoming a more prominent threat to the world's biodiversity (Clough *et al.*, 2011). In the neotropical region, local and largescale agricultural intensification is a major driver of biodiversity loss (Clough *et al.*, 2011). Developing sustainable farming methods is crucial to preserving these complex ecosystems that a multitude of organisms and communities so direly depend on. Agroforestry is one of the most important tropical agricultural systems, covering over 6.4 mil km^2 (13%) of agricultural land (Clough *et al.*, 2011). Agroforests can be designed to optimize both biodiversity and crop production benefits without adding pressure to convert natural habitat to farm land (Clough *et al.*, 2011). Moderate shade, adequate labour and input level can be combined with a complex habitat structure to provide high biodiversity as well as high yields (Clough *et al.*, 2011). Tropical agroforests have a high biological conservation potential because they can connect forest fragments and habitats to allow movement of organisms as well as the natural dispersal of slow-growth, shade tolerant trees (Clough *et al.*, 2011). Agroforest vegetation structure can both mimic natural forest habitat and promote natural regrowth (Clough *et al.*, 2011). In a study performed by Clough *et al.*, (2011) it was observed that more birds and forest (non-planted) tree species were found in cacao agroforests associated with a higher number of taller trees. The presence of deadwood and leaf litter also appeared to benefit birds, as well as other organisms such as reptiles and amphibians (Clough *et al.*, 2011). By monitoring the abundance of certain organisms as agroforests mature it is possible that one could track how agroforests impact biodiversity in secondary growth tropical forests.

Bird Surveillance

A survey is a reliable estimate or index of a population size of a particular species in a given area (Gregory *et al.*, 2004 and Bibby *et al.*, 1992). Bird surveillance can be an important research tool, providing that suitable environmental data is collected (Gregory *et al.*, 2004 and Whitman *et al.*, 1997). A survey would be an appropriate method to determine how many individuals of a specific bird are present, or to gather baseline info for an area that is poorly known (Gregory *et al.*, 2004, Bibby *et al.*, 1992 and Whitman *et al.*, 1997). If repeated at regular intervals, over a long period of time, this could allow to track changes in bird populations (Gregory *et al.*, 2004 and Whitman *et al.*, 1997). For example, if an area is being developed, analysing these trends could help assess the likely impact of development on the conservation value of the land (Gregory *et al.* 2004). Consistency of the survey method is crucial to measuring genuine population fluctuations (Gregory *et al.*, 2004 and Bibby *et al.*, 1992).

Birds as Ecological Indicators

Birds can be excellent indicators of wider environmental health particularly when assessments use summarized data from a wide range of species (Gregory *et al.* 2004). Some species can be more sensitive to changes in abiotic factors or habitat, while some species can be generalists (Gregory *et al.* 2004). Collecting data of a wide range of abiotic and biotic variables over a long period of time is useful when analyzing changes in populations (Gregory *et al.* 2004). Well-designed surveys can provide early indicators towards the underlying causes of trends in species numbers and can potentially ascertain the success or failure of conservation actions in order to determine priorities (Gregory *et al.* 2004 and Whitman *et al.*, 1997). It is important to note that most reliable surveys are performed over a long period of time and include a wide sample size as well as a variety of variables (Gregory *et al.* 2004, Volpato *et al.*, 2009 and Whitman *et al.*, 1997).

The Native Food Forest

The Native Food Forest, located at Finca Las Piedras, in the Madre de Dios in the southern Peruvian Amazon (S 12.22733 W 069.11277), is an excellent example of developing agroforest. The Native Food Forest encompasses 8400 m^2 of reforested abandoned agricultural field, containing over 800 individual plants of 26 species that are crucial to re-establishing the natural habitat (ASA biannual report 2018). Each species holds a significant ecological and economical value: timber species such as *Dipteryx odorata*, fruiting species such as Cacao and Inga, as well as other species that are important for providing shade and restoring wildlife such as Brazil nut and Lupuna (ASA biannual report 2018). This agroforest was developed by the Alliance for a Sustainable Amazon and serves as a living seed bank, providing a base for reforestation projects in the surrounding area (ASA biannual report 2018).

Study Focus

The purpose of the study is to document what bird species are using the Native Food Forest as it develops and to determine whether it is more beneficial to monitor in the morning, during the dawn chorus, or the evening, when the birds return to roost. This is an experimental project in which the main goal is to test a generic field method to successfully survey a large variety of species in a specific habitat. The survey method implemented was designed to increase accuracy and precision while reducing bias. Important points to consider if the study were to continue are discussed in the paper [See: 4. Discussion]. Because the study was completed over a short period of time, trends seen with the data collected could differ if a larger sample size is used.

Methods

The study was conducted over a period of seventeen days, beginning on July 2, 2019 and ending on July 18, 2019. Data collection took place over a total of nine days. Eight days were allocated to data review, analysis and report writing. This study was performed by Alessandra Wilcox (B.Sc. Wildlife Biology and Conservation, University of Guelph). Additional observers participated occasionally with all observations recorded on one form. Within this study a true census was conducted within the Native Food Forest. The census included 4 key point transects, which were spaced to optimize observation range within multiple habitats in the Food Forest, from which data was collected. Special considerations were made when developing the survey design to optimize observation of a wide range of species, and reduce bias while increasing accuracy and precision of the study. Prior to the beginning of the study, several days were allocated to study the identification of local bird species.

Study Area

The Native Food Forest is located in the Madre de Dios Region in the southern Peruvian Amazon [S 12.22733 W 069.11277]. This agroforest is one of the

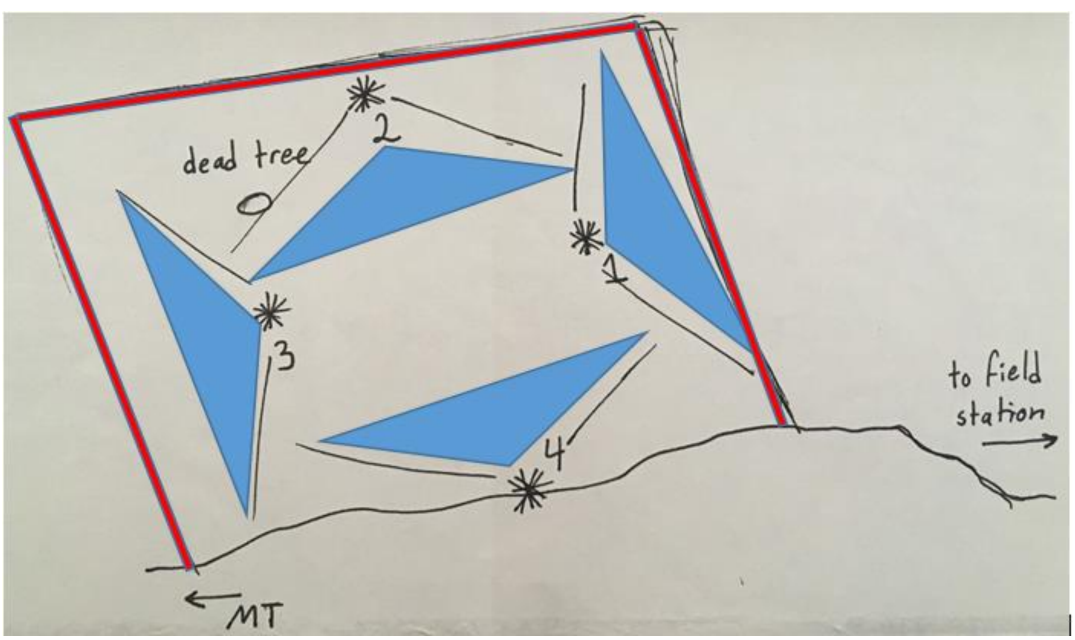

Figure 1: Sketch of Native Food Forest and the approximate location of the points (at the asterisk), in reference to each other, at which the survey was conducted. The blue triangles depict the main area of visual focus when surveying these points. The red lines depict the boundaries of the forest

many ongoing projects at the Alliance for a Sustainable Amazon field site. The Native Food Forest consists of 8400 m^2 of reforested abandoned agricultural field, containing over 800 individual plants of 26 species that are crucial to re-establishing the natural habitat (ASA biannual report 2018). This forest is still in early developmental stages and secondary growth forest is the primary habitat within the boundary (ASA biannual report 2018). Four points were chosen within the Native Food Forest in order to cover as much habitat variation and area as possible [Figure 1]. A description of each is as follows: 1. [S 12.22773 W 069.11294] Edge forest habitat consisting of grasses, dense shrubs, Kudzu, and minimal to no ground visibility, 2. [S 12.22839 W 069.11276] Central area of the Food Forest consisting of mid-height Cecropia, light shrubs, and medium visibility, 3. [S 12.22781 W 069.11251] Edge forest habitat consisting of Kudzu, light shrubs, and great visibility and 4. [S 12.22733 W 069.11277] Edge forest habitat consisting of Kudzu, developing cacao, and great visibility of southern half of the Food Forest.

Survey Design

An hour census was conducted twice a day, one beginning at 5:30am and the other at 4:30pm with the purpose of counting and identifying all birds within the survey boundary. These times were chosen to optimize periods of peak bird activity: during the dawn chorus, and when species settled to roost (Volpato *et al.* 2009). A generic field method was utilized in order to encompass the identification of all species well. Point transects were chosen as the method of survey in order to assess as much area as possible over a variety of dense habitats that were hard to access (Whitman *et al.*, 1997). The point count method is one of the most common methods to survey birds in forest ecosystems of tropical regions because it doesn't require access across the whole survey area (Gregory *et al.,* 2004, Volpato *et al.,* 2009 and Whitman *et al.*, 1997). This method suits dense habitats such as lowland forest or scrub. It is also optimal for cryptic, shy, skulking, species common to lowland tropical forests (Gregory *et al.*, 2004, Bibby *et al.*, 1992 and Whitman *et al.*, 1997). This method involves mainly auditory detections of birds within fixed radius plots (Volpato *et al.,* 2009). Accuracy and efficiency are increased by the observer's effort, which affects information on species abundance (Volpato *et al.*, 2009 and Bibby *et al.*, 1992). Intense observation occurred at regular intervals along the chosen route and for fifteen minutes at each of four points. The order of the points visited during each census was randomized using the RANDBETWEEN function on Excel 2013.

Abiotic Factors

Abiotic environmental variables were recorded twice a day before each census formally began. Precipitation was measured ±0.5mm using a precipitation gauge. The presence of mist was recorded: yes, indicated by 1, or no, indicated by 0. Cloud cover was recorded on the scale of 0-4: 0 being no cloud cover, 1 being patchy or very far spaced clouds, 2 being patchy clouds closer together, 3 being mostly cloudy with patches of clear sky, and 4 being complete cloud cover. A thermometer was placed within the forest interior and the high, low, and current temperature was continuously recorded.

Species Observation and Identification

At the beginning of each census a timer was started while approaching the first point in order to record the amount of time spent at each point. For birds that were observed visually, each species, as well as the number of observed birds, was recorded. If the bird was heard then only the species was recorded and observation type was indicated with an "X". If a species was seen, following being marked down as heard, the number of individuals of the species was recorded and the "X" was omitted. Bird species and numbers that were observed flying over the Food Forest as well as heard or seen along the edge were recorded as separate data, while still following standardized methods of recording seen and visually observed birds, as these could not be included in the standard density estimation. Birds were recorded at the first point they were initially observed and flushed birds as the observer approaches the point were also included. Double-counting was avoided by keeping track of previously observed birds, a skill which increased in effectiveness with progressed training and familiarity with the survey boundaries. In order to reduce bias on the account of limited training on identifying neotropic bird species, the video recording application on an iPhone SE was used to record sound within the period of time spent at each point. After each census was complete the recordings were reviewed and organized accordingly in order to simplify the identification process. Identification of recorded calls took place at the end of each data collection week on days allocated for data analysis. Visual identifications were confirmed using the ©Birds of Peru application.

Data Analysis

All raw data was entered into an Excel 2013 form with a separate spreadsheet for data collected in the morning and data collected in the evening. Both spreadsheets were formatted identically. The top row was labeled with the variables: Date, Point Transect (1, 2, 3, or 4), Habitat (FF for Food Forest, FO for Fly Over, or FE for Forest Edge), Cloud Cover (CC), Current Temperature (T), Maximum Temperature (TH), Minimum Temperature (TL), Mist, Precipitation (in mm) and Coordinates (for each point). Each bird species observed was labeled, using the appropriate four letter code, across the spreadsheet in the same row as the variables. The data was filled in under the variables accordingly, and the number of individual birds seen with respect to the variables was filled in under each species column. If the bird was heard then an X was recorded instead of a number. A separate sheet was then created for each data set in which the data was copied including only the bird species and the respective data columns. The marked X's in these data sheets were replaced with the number 1 in order to make the data for the abundance graphs easier to work with. At the bottom of each species column the total number of individual birds of each species was recorded using the function SUM. Following this, a separate sheet was created to isolate abundance graph data. On this sheet three tables were made for Total Abundance, Morning Abundance, and Evening Abundance. The variables Species, and Number were labelled in the row under each title. Under each Species column, the four letter code of each species was recorded and, using the total summed data from the previous excel sheets, the total number of individual birds of each species seen in both the morning and the evening was recorded next to the respective species code. This data was then organized from the most abundant species to the least abundant. This process was repeated for both the Morning Abundance and Evening Abundance tables, however the order of species down the column was the same format as the order of species under the Total Abundance table. Three Abundance graphs were then created using the data from each table [Figure 4, Figure 5, and Figure 6].

A separate excel sheet was then created to isolate data for box graphs. On this sheet, the variables Habitat, and T, were copied from the master data sheets, and variables Morning and Evening were added to the top row. Under the Morning and Evening columns, the total number of individual birds observed with respect to each habitat at each temperature was recorded. Using this data a GLM analysis was run using R programming, for both the Evening and Morning data sets, in order to determine if there was a difference in abundance at different temperatures [Figure 7 and Figure 8]. Box plots were created for each data set [Figure 9 and Figure 10].

The number of species seen in both the morning and in the evening were summed, as well as the total abundance for each time of day, and recorded on a separate excel sheet. Two bar graphs were created to display both the abundance and number of species, for morning and evening, in order to visualize the discrepancy between each time of day [Figure 2 and Figure 3].

Results

Species Composition, and Abundance

A total of 2127 birds were observed over the 17 days this study was conducted. A toStal of 1162 individuals were observed of 58 species were observed in the morning, and total of 965 individuals observed of 53 species were observed in the evening [Figure 2 and Figure 3]. The most abundant bird species observed in the morning was crested oropendola (104), and the most abundant in the evening was red bellied macaw (173). Red bellied macaw was also the most abundant bird species in total [Figure 4]. There was a higher recorded abundance of unknown calls in the morning (62) compared to almost half as many unknown calls in the evening (33). Sixteen species of birds were only observed in the morning: GBMA, SPGU, LTHE, DCAT, BYMA, AMTR, COTR, ORHE, BBGR, SNEG, GREG, BGTA, TSOW, MATI, BTSA, and COPA [Figure 5]. Ten species were only observed in the evening: BANA, RGDO, TUVU, CBTO, GFDO, STHA, BLVU, PATA, SQCU, and SIRY [Figure 6]. There was an overall higher abundance of species and individual birds seen in the morning compared to the evening [Figure 2 and Figure 3].

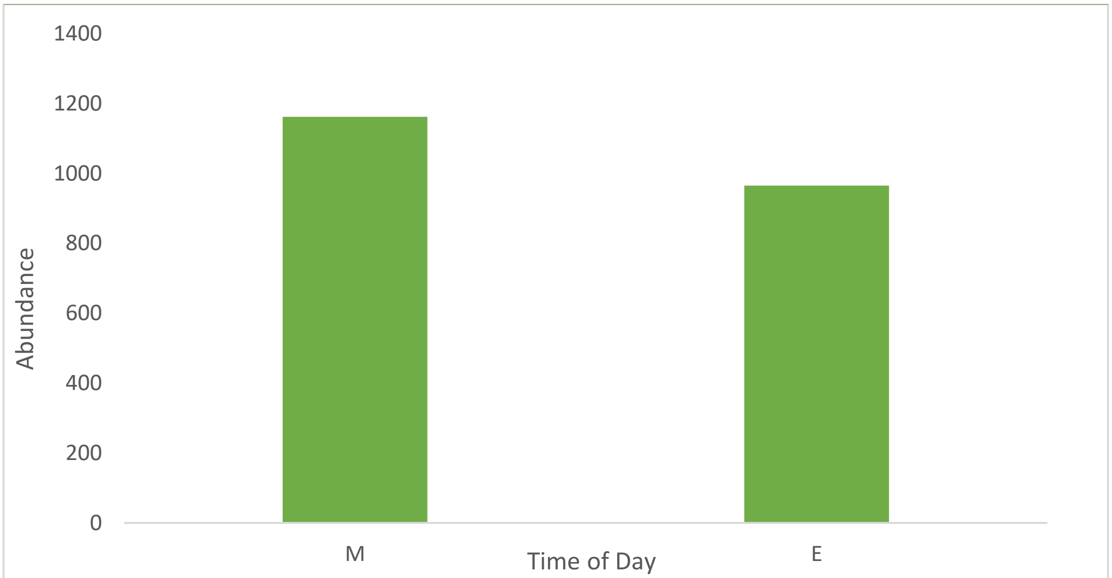

Figure 2: Bar chart comparing the abundance of birds in the morning and in the evening. There was a higher abundance of birds in the morning than the evening.

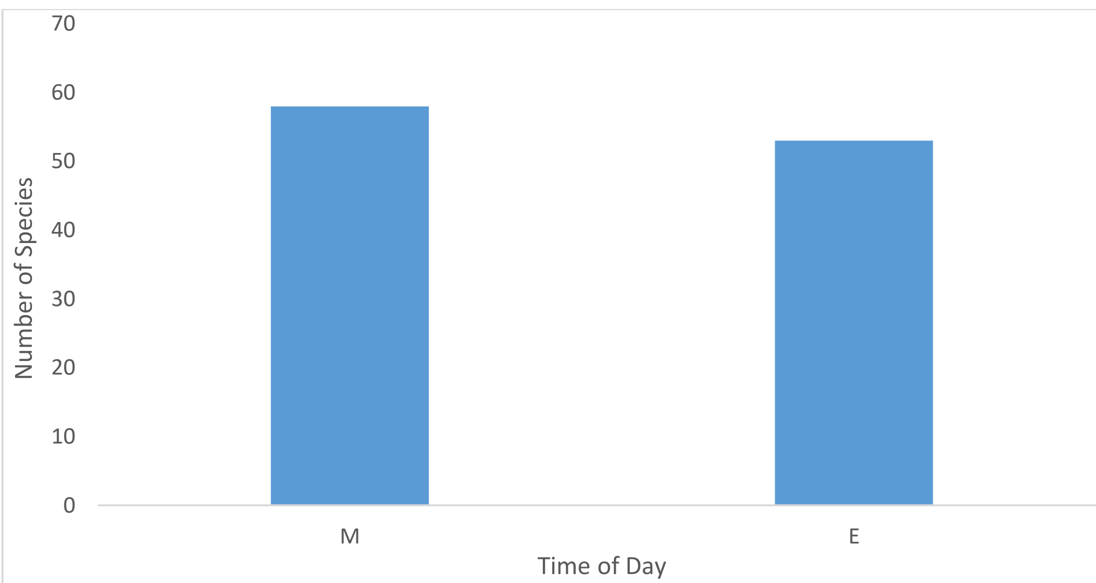

Figure 3: Bar chart comparing the number of species observed in the morning and in the evening. There was a higher number of bird species seen in the morning than in the evening.

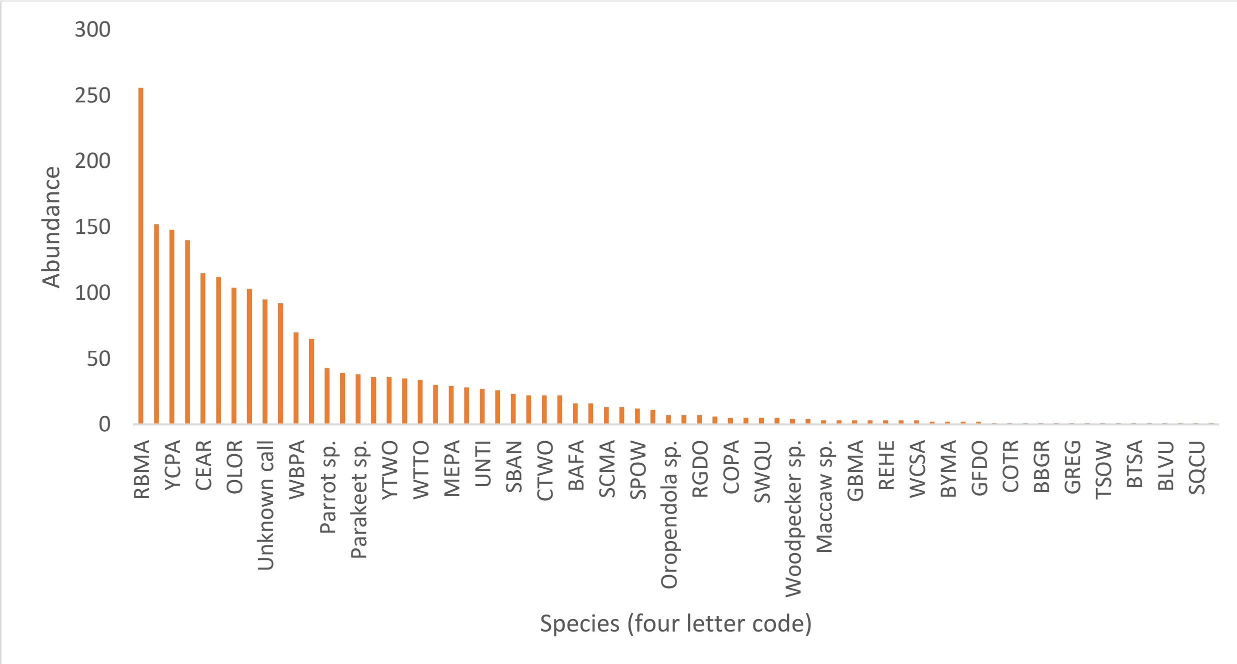

Figure 4: Relative abundance graph for the total data set showing number of individuals per specie.

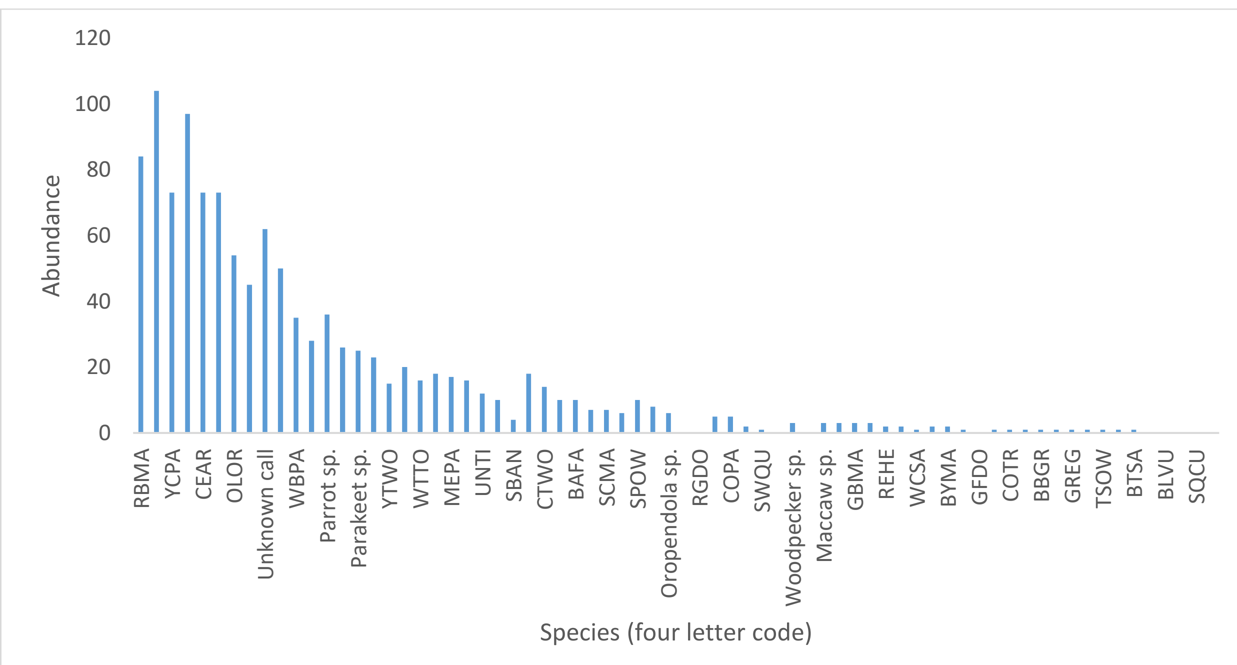

Figure 5: Relative abundance graph for morning data set.

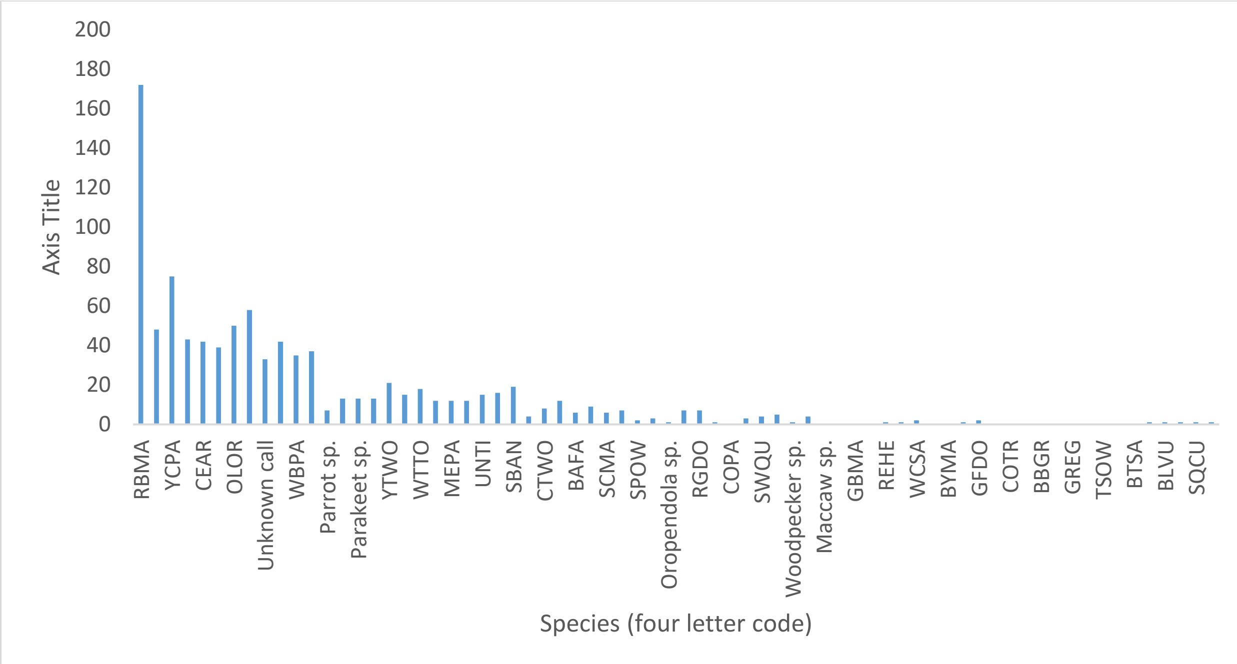

Figure 6: Relative abundance graph for the Evening data set.

Influence of Time of Day and Temperature on Species Abundance

According to the GLM analysis for the Morning data, the p values for variables Food Forest and Forest Edge were highly significant and the p values for Temperature and Forest Edge were not significant [Table 1]. This means that habitat has a significant impact on bird abundance in the morning, but temperature does not [Table 1]. The model suggests that in in the morning there were significantly more fly overs observed than birds in the Food Forest or in the Forest Edge [Figure 9]. According to the GLM analysis for the Evening data, the p values for variables Temperature and Forest Edge were highly significant, the p value for Fly Overs was slightly significant, and the p value for Food Forest was not significant [Table 2]. This means that temperature and habitat have a significant impact on bird abundance in the evening [Table 2]. In the evening, the model suggests that the variables Forest Edge and the Fly Overs differ from the Food Forest [Figure 10].

Table 1: This table depicts the results from the GLM analysis for the morning. The asterisk signifies significance.

	y	**df**	**p value**
T	11.5971	107	0.239
FF	24.1328	107	>0.05***
FO	20.7995	107	>0.05***
FE	12.0217	107	0.115

Table 2: This table depicts the results from the GLM analysis for the evening. The asterisk signifies significance.

	y	**df**	**p value**
T	65.7164	107	>0.05***
FF	66.482	107	0.54
FO	74.7876	107	0.0292*
FE	68.2598	107	>0.05***

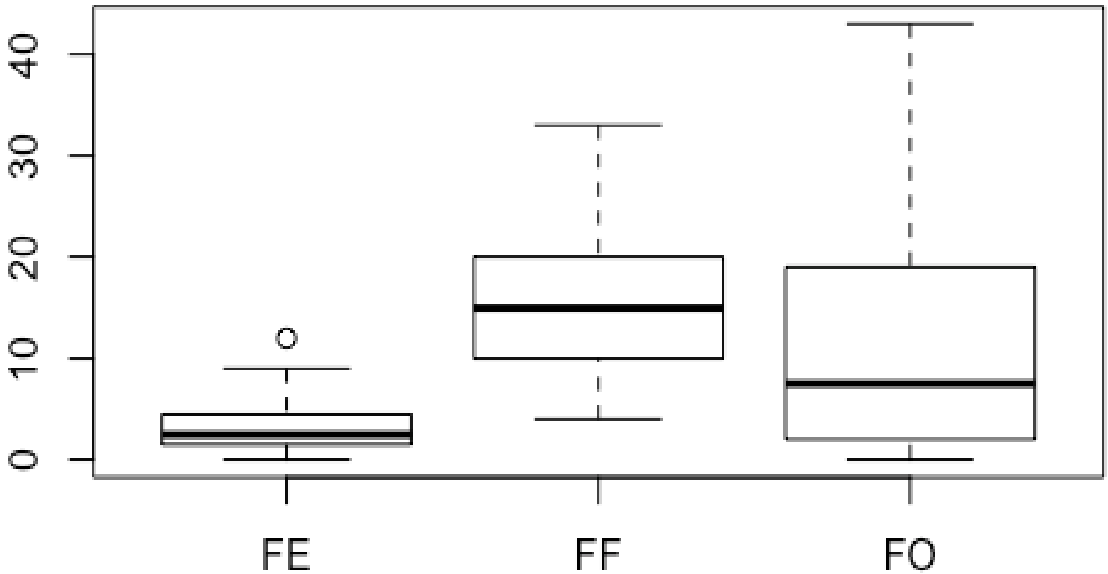

Figure 9: This is a box plot displaying data from the GLM analysis for the morning.

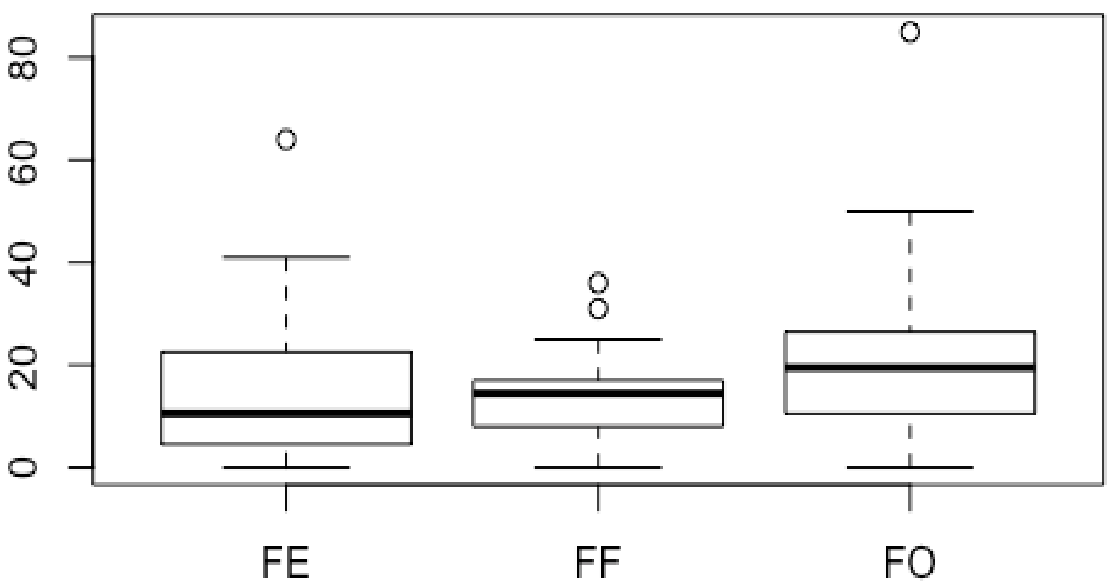

Figure 10: This is a box plot displaying data from the GLM analysis for the evening.

Discussion

Species Composition, and Abundance

There was an overall higher abundance and number of species in the morning compared to the evening. However, in both cases there is only a slight difference in value (58-53 and 1162-965), and a significant difference between these two number sets was not tested. Perhaps these numbers represent early trends and depict that there is a higher abundance and number of species in the morning. It is possible that not enough data has been collected. If the study had been conducted over a longer period of time and included a larger sample size, the data could depict different results, or conclude the trends that are presently observed. An important fact to note however is that almost twice as many unidentified calls were observed in the morning than in the evening. This means that more birds were vocally detected in the morning rather than in the evening. A possible explanation for this is that birds are probably more vocal in the morning and therefore easier to detect in the undergrowth. The overall less abundance of birds in the evening might be due to the fact that less birds are vocal and therefore harder to detect in the dense habitat.

Influence of Time of Day and Temperature on Species Abundance

An important result from the GLM analysis was that in the morning there was a significantly higher incidence of fly overs observed than birds observed in the Food Forest or forest edge. A possible reason for there being less observations in the forest edge could be that it is more difficult to detect birds by sight in the dense undergrowth. It is easier to observe birds flying across the forest clearing than it is to observe birds in the brush. In the Food Forest habitat, the main method of observation was by sound. Another possibility could be that there is less of an abundance of birds within the Food Forest interior than in the forest edge or flying over due to the forest clearing and lack of suitable habitat for some species. This trend could change over a longer period of time as the Native Food Forest matures. A more mature forest provides taller trees, different levels of plant growth, shade, a higher variety of plants, leaf litter, as well as a number of other variables some species of birds might prefer. This could result in a higher number of birds stopping in the Native Food Forest rather than flying over or across it.

Conclusion

In conclusion, there was a higher abundance of birds and a higher number of species observed in the morning compared to the evening. The point count method was a suitable method for the Native Food Forest habitat and survey type. It would be more beneficial if this study were to take place over a longer period of time, or it were to be continued, in order to present the most accurate trends. This study produced early trends that can be verified by further study, and can act as the base or pilot data for a more thorough study in the future. It is incredibly important to continue to study the potential impacts of agroforestry so that we can create a widespread solution to the harrowing effects of current agricultural expansion.

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